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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

VOLUME 4 NUMBER 41 MAY 1958

TIDYING UP THE MAP

LIKE THOSE MYSTERIOUS BLANK AREAS IN THE atlas of the world, such as Greenland and the Mato Grosso, there have been parts of The Institution's map of the British Isles which lacked the bright colouring of the Centre and Sub-Centre territories—remote mountains of Westmorland and desolate marshes of the East Coast, hitherto untrodden by the foot of the electrical engineer. But irresistibly the electrical industry grows, and into the virgin lands go the power lines and telephone cables, the paraphernalia of the electrical age, and members of The Institution to supervise it all.

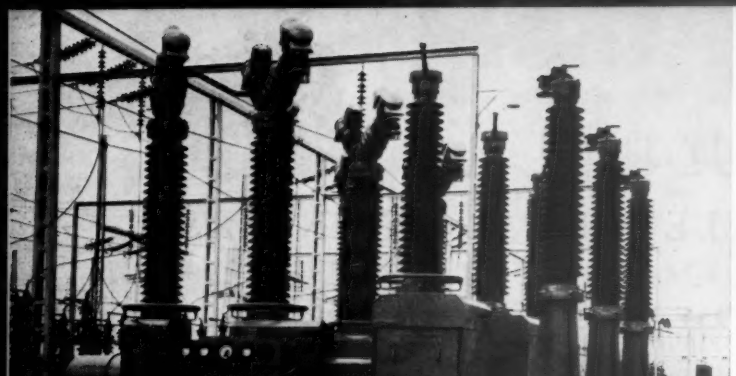
In recent years a fair number of members have settled in the white areas, unattached to a Local Centre, though welcome, of course, as all members are, to attend the meetings of any Centre to which they are pleased to go. The coverage of the British Isles began in 1899, when Local Centres (then known as Sections) were formed in Dublin, Newcastle and Glasgow—with a fourth, rather surprisingly, at Cape Town. Since that time the system of Local Centres has gradually expanded to provide meeting facilities for more and more members. There are now ten Centres and eleven Sub-Centres.

The Study Committee appointed by the Council in 1957 to review the Local Centre organization suggested that the possibility of absorbing the remaining white areas within the adjacent Centres should be looked into, and also that the present Centre boundaries should be examined with a view to providing better facilities for members in the fringe areas. In accordance with this suggestion, the Local Committees have considered the matter, and already certain proposals to cover the remaining white areas remote from London have been adopted, thus completing the process started in 1899.

Until recently, the Isle of Man (20 members) and parts of Westmorland (3 members) and North Lincolnshire (53 members, of whom 33 are in Grimsby) have not been included within the Local Centre organization, but, as announced on p. 279, the Council have now authorized measures to remedy these anomalies. The Isle of Man is to be allocated to the Mersey and North Wales Centre, the white area of Westmorland to the North Lancashire Sub-Centre and the white area of Lincolnshire is to be divided between the Sheffield Sub-Centre (of the North Midland Centre) and the East Midland Centre. These new boundaries have been fixed in consultation with the Local Committees concerned, the decision being based on the number of members residing in each white area and their access to the meeting places of neighbouring Centres.

Apart from the inclusion of the white areas, the Local Centre boundaries have been adjusted in other ways. Many members living in the regions of Oswestry and Whitchurch (Shropshire) have found it more convenient to travel to the meetings of the Mersey and North Wales Centre than to those of their own Centre, the South Midland. Accordingly these districts are being transferred to the former Centre. Other modifications are still under discussion. In fixing the boundaries of the Local Centres and Sub-Centres, the first consideration is the convenience of members, rather than any special regard to county, Post Office regional or other existing boundaries. In any case, members in fringe areas have the option, under the existing Council Regulations for Local Centres, of attachment to the Centre of their choice, notwithstanding the boundaries fixed by The Institution, it being recognized that although a member may live in one Centre it may suit him better to be attached to another.

The only remaining area, apart from London itself, not covered by the Local Centre organization is that of the Home Counties, because most members living there experience little difficulty in attending meetings at Savoy Place. There are, however, some in the outlying towns of this area who cannot conveniently travel to London, and these members are provided for by District Meetings at Bedford, Hatfield, Maidstone, Oxford and Reading. District Meetings originated in the Local Centres, which attempted by means of these more informal types of meeting—preferably grouped around a good fire—to provide facilities for members in the more sparsely populated outlying areas. The attempt has turned out to be very successful, and the scheme represents a significant post-war development in the local organization.



Four-break 150 kV 7500 MVA circuit-breaker in course of erection in the Netherlands

An Electrical Engineering Review

AIR-BLAST CIRCUIT-BREAKERS FOR VERY HIGH VOLTAGES

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This review article has been prepared to present the subject of air-blast circuit-breakers, which is essentially a specialized one, simply and in such a way that it will be of value to the reader who is familiar only with the more general aspects of circuit-breaking. Air-blast circuit-breakers are used mainly for the higher-voltage and larger breaking-capacity ratings encountered in electricity supply systems, and while the principles of operation are common to all designs there are many of these with a variety of applications and special features. The circuit-breakers described are for operating voltages over 100 kV, a range in which development is rapid and vigorous, and much interest has been aroused. Mr. Simpson is Engineer-in-Charge of High-Voltage Switchgear with A. Reyrolle and Co., Hebburn.

G. K. SIMPSON, B.SC., A.M.I.MECH.E.,
ASSOCIATE MEMBER

THE use of an air blast was long ago recognized as an effective means of circuit breaking, but it has not been applied extensively until recent years because of the suitability of bulk-oil circuit-breakers and the ready availability of oil. A number of factors including oil shortage, high oil costs, oil fires in service and higher-breaking-capacity requirements have encouraged the development of the air-blast circuit-breaker until it has become a serious competitor to the oil circuit-breaker. It has the advantages of high operating speeds and elimination of oil filling, with its inherent fire risk and oil carbonization problems, but additional complexity and cost of compressed-air supplies are among the disadvantages. The development of the small-oil-volume circuit-breaker has done much to restore the balance, in respect of reducing the quantity of oil used while preserving the mechanical simplicity of the bulk-oil circuit-breaker.

At present a British Standard for air-blast circuit-breakers is in course of preparation; when it is issued the air-blast breaker will become truly established alongside the oil circuit-breaker, the only high-voltage circuit-breaker at present covered by a British Standard (B.S. 116). Its special features and requirements will be recognized by this document, which should form a useful addition to the practice of circuit-breaking.

Requirements of Very-High-Voltage Circuit-Breakers

Larger systems and larger plant in the form of generators and transformers increase the circuit-breaking duty because of the larger short-circuit power available. Added to this is the severity of the restriking voltage transient as determined by the natural frequency and the amplitude of the recovery voltage of the system. Short break times and high opening and closing speeds are required in circuit-breakers so that short-circuits may be interrupted in the briefest possible time, and advantage may be taken of single-phase or three-phase auto-reclosing in order that system stability may be preserved during the clearance of transient faults. However, should loss of synchronism occur, then the circuit-breaker must also be capable of separating the two parts of the system which are out of step.

The ability to handle short-circuit conditions is only one of the requirements of a high-voltage circuit-breaker. In addition, it must be able to break off-load currents such as the magnetizing current of a power transformer or the charging current of an overhead line or underground cable, and the transient voltage must be kept to a safe limit. It must also be able to operate repeatedly without undue maintenance, as, for example, when required to switch a generator circuit twice a day, and if mounted outdoors, to operate in all climatic conditions ranging from tropical to arctic.

The considerable amount of testing necessary to establish the suitability of the equipment for the required duties is done, as far as possible, in the laboratories of the manufacturer. However, some tests are still often best made in the supply system itself. Such tests are the switching of unloaded lines or power transformers, the exact characteristics of which are difficult to reproduce in a testing station.

For very high voltages, particularly if large breaking capacities are required, it is generally found that the optimum circuit-breaker that can be produced consists of a number of similar circuit-breaking units in series

The main reason for this is that if one unit can be fully tested with the existing testing station capacity, the performance of the circuit-breaker can be deduced; on the other hand, to provide a testing station large enough to test the complete circuit-breaker fully would be excessively costly, and other methods of proving, by synthetic means, or by tests in the field, all leave something to be desired.

It is generally accepted that the air-blast circuit-breaker is ideally suited for the largest switchgear requirements at the highest voltages, mainly because of its good performance under the great variety of switching conditions but also because its compressed-air operation simplifies the mounting of a large number of breaking units in series. The breaking units themselves can be completely separate and identical, which enables the principles of proving by unit tests to be applied with greater confidence. The risk of fire is negligible, and there is little or no deterioration in performance under the most arduous switching requirements.

Typical Air-blast Circuit-breaker

The essential components of an air-blast circuit-breaker are a vessel in which the compressed air for operating the circuit-breaker is stored; a blast valve which releases the compressed air when the circuit-breaker opens; interruptor contacts which operate in the air blast to extinguish the current through the circuit-breaker; and the necessary insulation across the circuit-breaker to afford isolation between terminals when the air-blast has been cut off.

Fig. 1 shows schematically one phase of a typical arrangement of circuit-breaker having two interruptors and a rotating air-break series-switch. To open the circuit-breaker, the trip coil is energized and the trip coil plunger opens the trip valve. This valve admits air from the air receiver via the change-over valve to the blast valve piston; the blast valve opens and air from the air receiver passes through the blast pipe to the interruptors, which are of the axial-blast type.

Each moving contact is carried by a spring-loaded piston which moves to the open position under the action of the compressed air, drawing an arc between the tip of the moving contact and the fixed nozzle contact. This arc is then rapidly blown into a central position through the nozzle to root on to a downstream arcing electrode, in which position it is extinguished.

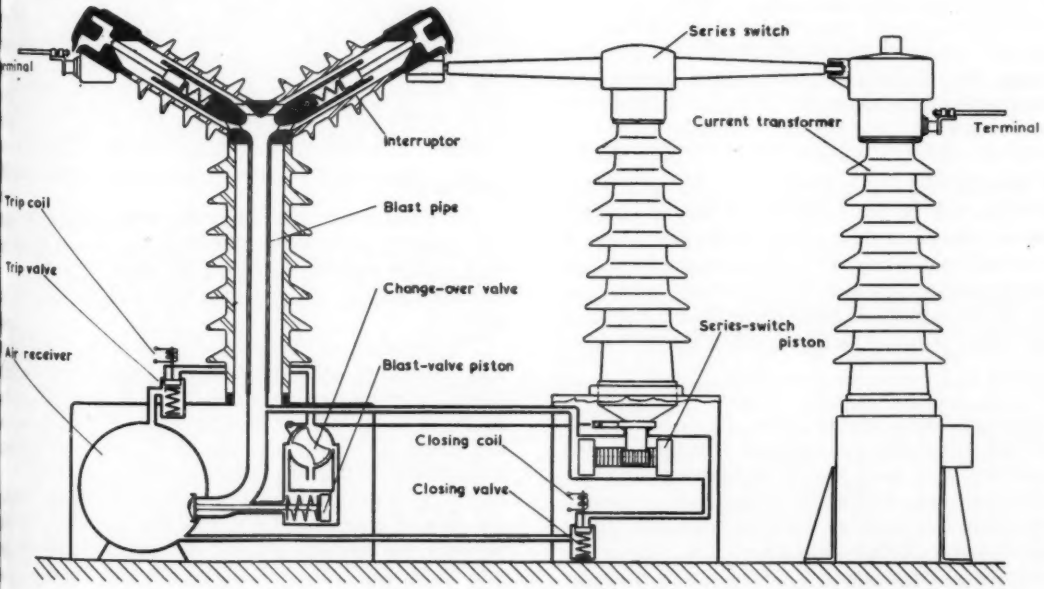
After an interval sufficient to extinguish the arc, compressed air from the blast pipe operates a piston causing the series switch to open. During its travel the series switch operates the change-over valve through 90°, cutting off the supply of compressed air to the blast-valve piston and allowing the blast valve to close. As the air pressure in the interruptors falls, the contacts return under spring pressure to their normally closed position and the tripping operation is complete.

To close the circuit-breaker the closing coil is energized and air is admitted by the closing valve to the piston causing the series switch to close. The interruptor contacts are not operated during closing.

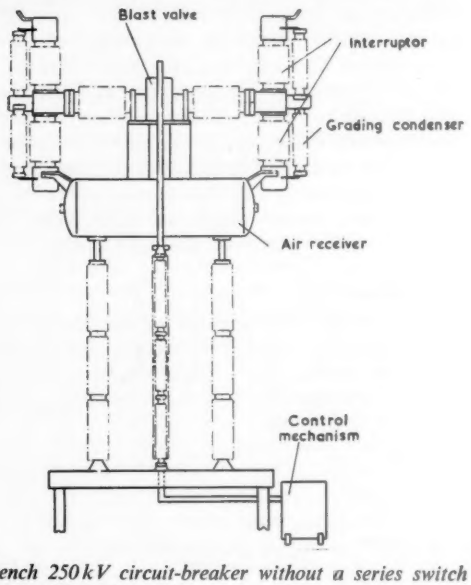
Air Consumption

A relatively large amount of compressed air is used when the circuit-breaker opens, perhaps several hundred cubic feet of free air, while the closing operation takes only a few cubic feet. It is usual to store sufficient air to

Schematic arrangement of a typical circuit-breaker



enable an auto-reclosing sequence of OPEN—dead-time—CLOSE-OPEN to be made, and the air consumption necessitated by this operating cycle is one of the leading parameters in the design of the circuit-breaker, being closely related to performance and cost. In most constructions of circuit-breaker the air-receiver is at earth potential, and the compressed air has to be conducted through blast pipes of insulating material to the level of the interruptors. A relatively large proportion of the total air consumption is used to fill these pipes, and it also takes a certain minimum time to establish pressure in the interruptors which depends upon the length of the pipes. In Fig. 2 the air receiver is fully insulated from earth, and while this enables the compressed air to be stored close to the interruptors, it introduces the necessity for insulated filling pipes and control pipes or



2 *A French 250 kV circuit-breaker without a series switch and with a 'live' air receiver*

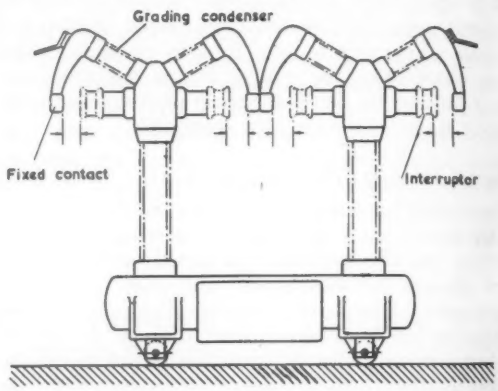
links to operate the valve gear. The size of the air receiver which can be mounted in this way is limited, and if there were more than a few breaks per phase, a number of such steel vessels would be required and this would present mechanical and electrical design problems. However, the possibility of adopting pressure vessels of insulating materials in the future must not be overlooked.

Insulation

The main insulation of open-type circuit-breakers is provided by high-grade porcelain in atmospheric air; these insulators are used in the supporting structure and also to transmit mechanical forces and pneumatic pressures to the live parts of the circuit-breaker. There are large-diameter hollow insulators for supporting heavy assemblies; pipes up to a few inches in diameter with or without sheds for blast and control pipes; so and hollow members for torsional mechanical operatio and post insulators of various types for built- supporting structures.

Oil is usually avoided completely for insulation air-blast circuit-breakers; in some constructions co pressed air is used, advantage being taken of the increa of electric strength with pressure. It may be confined the insulation between contacts in the open position in an earthed tank containing the interruptors; in metalclad design, it may be utilized also as the ma insulation to earth.

As already mentioned, the insulation across t circuit-breaker in the open position is often provided



3 *A German 110 kV circuit-breaker in the open posit showing the four air breaks*

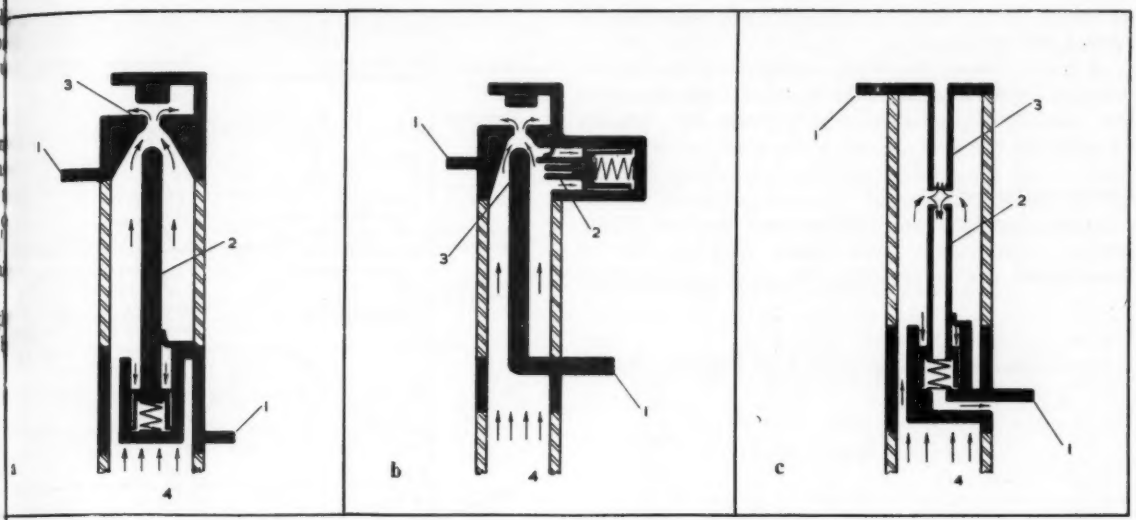
a series switch having a single or double break in atm spheric air. However, if the contacts of a multi-bre circuit-breaker are arranged to move through an clearance, as shown in Fig. 3, the insulation is th provided by a number of air breaks in series.

If the circuit-breaker is filled with compressed when open, the main contacts can provide inter isolation, and again a series switch is not necessary.

Interruptors

The interruptors used in multi-break circuit-break are generally of the types shown in Fig. 4: (*a*) axial fl with axially moving contacts; (*b*) axial flow with si moving contacts; or (*c*) radial flow with axially movi contacts.

The principle of operation of each type is similar, that a short arc, often less than one inch, is drawn by moving contact in high-pressure air. It is swept rapi by the high-velocity air flow through an orifice, and hot gases and products of arcing are exhausted atmosphere. Extinction occurs at a current zero beca of the rapid deionization and cooling of the arc path the flow of compressed air, and the insulation stren between the suitably shaped electrodes increases a rate which will withstand the recovery voltage.



Types of interruptor

a Axial flow with axially moving contact.
b Axial flow with side moving contact.
c Radial flow with axially moving contact.

1. Terminal.
2. Moving contact.
3. Fixed contact.
4. Blast pipe.

Mention should be made here of the valuable contribu-n made by the Electrical Research Association to the elopment of the air-blast interruptor. The work of Association and its original patents date from the eteen-twenties and early nineteen-thirties, and the hniques then established are still the basis of modern erruptors.

The moving contact in the interruptor may be opened the air pressure directly or by a separately driven air tor in the mechanism acting through an insulated e link. After arc extinction the contact may move to ully open position, or if a separate series switch is vided it may reclose by means of a return spring n the air pressure is removed. The interruptors shown ig. 4 are for use with a series switch, and this enables contacts to be designed for the breaking function , since the making duty is done on the series switch.

age Distribution

o be able to predict the performance of a multi-break uit-breaker from the test results of a single interruptor total duty must be shared between interruptors which identical in all respects and subjected to a controlled ribution of voltage. The natural distribution of age between interruptors depends upon the relative es of the series capacitances between contacts and leakage capacitances to earth. In a four-break uit-breaker as much as 60% of the total voltage may r on the worst stressed break (Fig. 5*a*). Impe-es in the form of capacitors or resistors may be d to the units to provide a series control current h corrects this uneven distribution of voltage . 5*b*).

Transient Voltages

An important aspect of the performance of the air-blast circuit-breaker is the limitation of transient voltages when opening reactive circuits. The majority of air-blast circuit-breakers are restrike-free when breaking capacitive currents, and therefore high transient voltages do not occur when switching unloaded lines or cables. However, when the load is highly inductive, current chopping may induce high voltages on the apparatus being disconnected; the main methods adopted to limit the voltage are to co-ordinate the contact gap so that it will restrike and automatically limit the voltage which can appear across the circuit-breaker, or to fit high-ohmic-value resistors across the circuit-breaker which may be either linear or non-linear, to damp the transient voltage oscillation. The resistor current may be broken by the series switch contacts or by compressed air in a special interruptor included in the resistor assembly.

Auto-reclosing

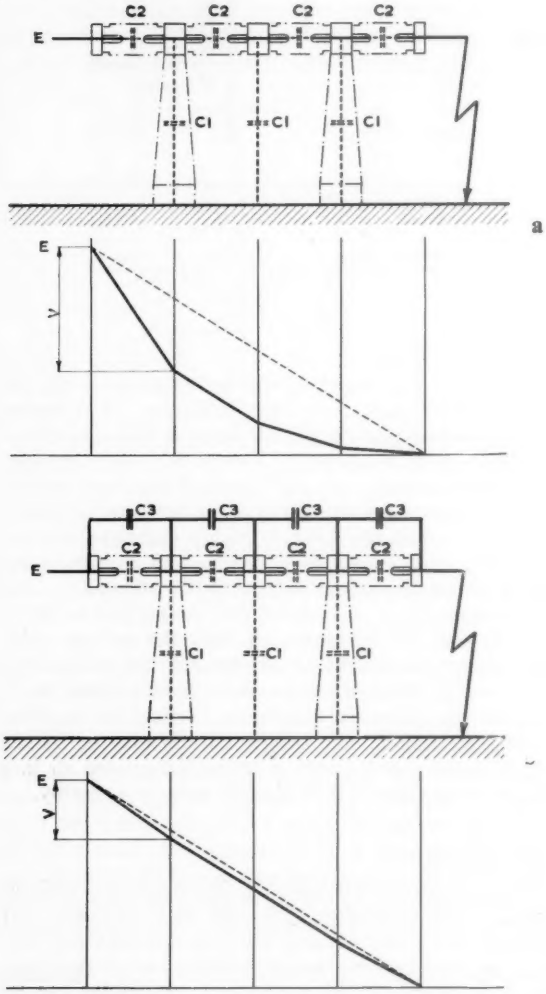
High speeds of operation are easily achieved with an air-blast circuit-breaker since the main impulses and driving power are derived from compressed air. For example, with suitably designed valves and air passages, the contacts of a 300 kV air-blast circuit-breaker can be opened in a time less than 0·04 sec, and with less than a cycle of arcing; the total break time is less than 0·06 sec. A typical record is shown in Fig. 6 of an auto-reclosing operation with a dead time of less than 15 cycles. It is not necessary for the series switch to open fully in the dead time, provided that the speed of make is not reduced. A dead time of 15 cycles is generally regarded as the

minimum during which a transient fault path may be cleared and deionized.

In some designs the series switch contacts are not operated in the dead time; the circuit is then remade by the interruptor contacts, which must be specially designed for this duty.

Current transformers

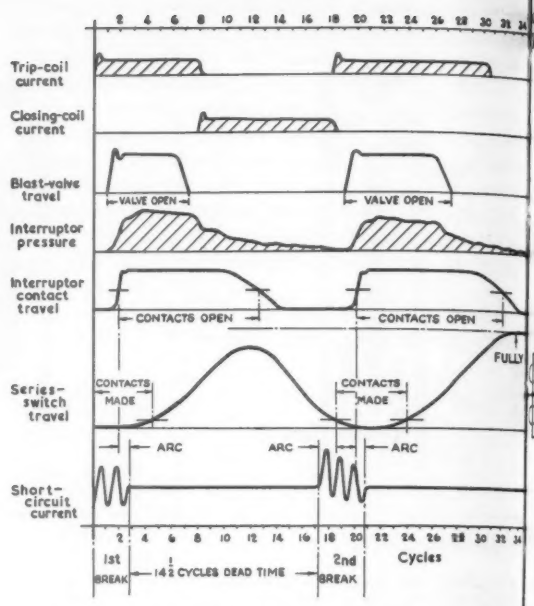
Unless bushings are incorporated in the circuit-breaker construction, over which ring-type current transformers can be mounted, the current transformers must be of the separately mounted post type or bushi type. If a series switch is included in the circuit-break the fixed contact may be mounted on the current tra former, as shown in Fig. 1, thus eliminating the need f a separate supporting insulator for this contact.



5 *Voltage distribution between interruptors of a four-break circuit-breaker*

a Without control. **b** With control.

C1 Leakage capacitance to earth.
C2 Capacitance between interruptor contacts when open.
C3 Added control capacitance.
E Voltage to earth.
V Voltage across the most highly stressed interruptor.



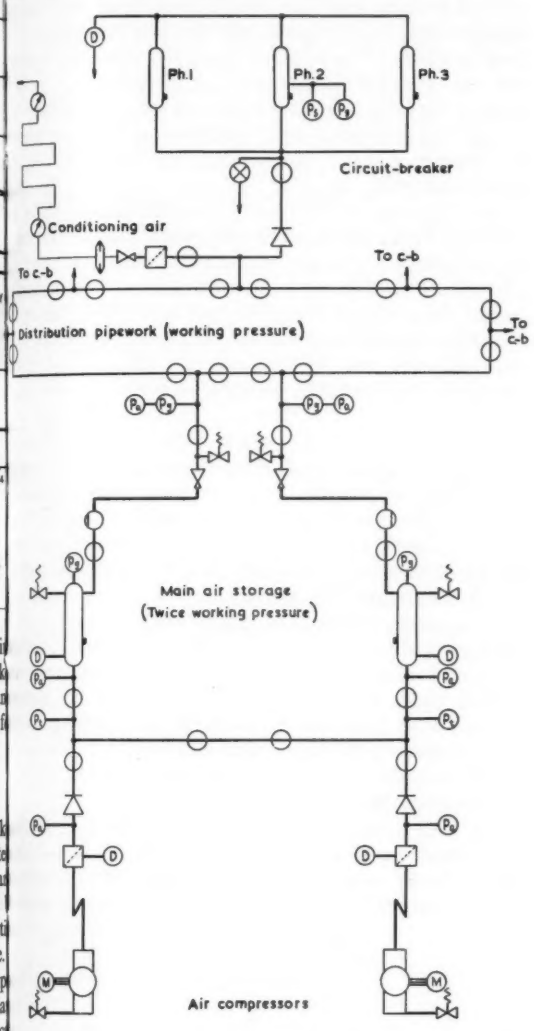
6 *Sequence of operations during high-speed auto-reclosing*

Compressed-Air Supply System

An essential part of an air-blast circuit-breal installation is the compressed-air system. On this syst the circuit-breakers rely for their operating power a internal insulation security, and it must therefore capable of supplying at any time the correct quanti and quality of compressed air at the correct pressure.

Reliability is obtained by using liberally rated comp nents which reduce maintenance, and items which ha to be maintained are duplicated so that the system c be kept in operation during a maintenance period. T quality of the compressed air is assured by the use filter equipment to remove solid particles and any oil a free water which may have been introduced during compression process. The air must also be of adequa dryness if the internal insulation of the circuit-breal is not to become contaminated by moisture. This achieved by removing the moisture contained in atmosphere either by refrigeration or the use of adsorptive drying agent, or by compressing to a press of the order of twice the working pressure and t expanding the air to the working pressure, usu between 15 and 20 atm, for distribution to the circ breakers. The latter scheme is adopted wherever possi and a diagram is shown in Fig. 7. In each circuit-brea a bleed of low-pressure conditioning air is circula

ontinuously over all the internal insulation surfaces to eep them dry and in good condition.



Symbol	Description	Symbol	Description
	Stop valve, open		Safety valve
	Stop valve, closed		Choke
	Blow-down valve		Air-cooler
	Flow indicator		Air-filter
	Under-pressure shut-down valve		Local air-receiver
	Pressure gauge		Main air-receiver
	Pressure alarm		Fusible plug
	Low-pressure switch		Drain-valve
	Reducing valve		Tee
	Non-return valve		Pressure stat.

Typical schematic of compressed-air system

Performance and Rating

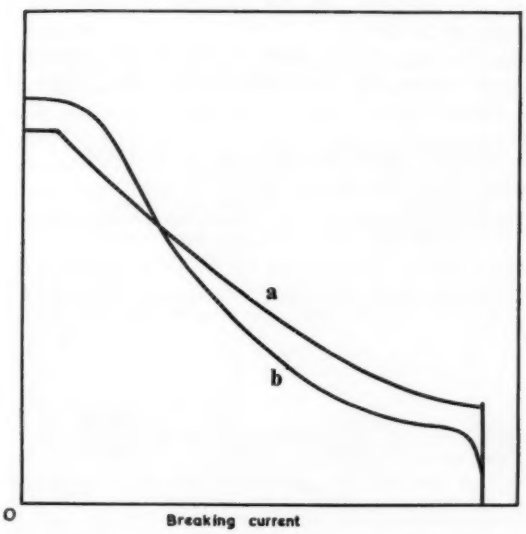
The trend in air-blast circuit-breaker construction continues to favour the open-type porcelain-clad arrangements for the higher voltages. The emphasis is placed on achieving lighter and simpler constructions with performance characteristics more closely matched to the system requirements. Multi-unit constructions enable circuit-breakers of a variety of ratings to be built up from basic components, and much importance is attached to the performance curves of the unit interruptor from which the performance of the complete range of circuit-breakers may be predicted.

Typical ratings of multi-break circuit-breakers

	150 kV	220 kV	275kV	380 kV
	MVA	MVA	MVA	MVA
4 breaks ..	7500	7500	—	—
6 breaks ..	—	10000	10000	—
8 breaks ..	—	—	15000	15000
10 breaks ..	—	—	—	20000

The performance of a single interruptor is related to the mass flow of air through the orifice during arcing. When breaking short-circuit currents at less than full rating the interruptor can clear with higher recovery voltages and rates of rise of restriking voltage, a characteristic which closely matches that found in supply systems. Typical curves are shown in Fig. 8.

By using a given unit interruptor, a minimum number of units is required in series for any particular voltage



8 *Performance curves of interruptor*
a Recovery voltage.
b Rate of rise of restriking voltage.

rating. This number of units, however, may be increased if a large breaking capacity rating is required, because, if the voltage per unit is reduced, a correspondingly larger breaking current may be interrupted, as shown in the table on the previous page.

Because of its inherent characteristics, the air-blast circuit-breaker can cater for out-of-synchronism switching conditions at double recovery voltage. Also, because the breaking conditions in the interruptor are practically constant, an evolved fault is easily handled.

Modern Constructions

Fig. 9 shows British air-blast circuit-breaker constructions in service and rated at 7500 MVA in the 275 kV system of the Central Electricity Generating Board. Fig. 9*a* shows an eight-break circuit-breaker with a centrally mounted rotating switch. The breaking units are in two horizontal groups of four, supported by the blast insulators at each end of the bed-plate, and are shunted by non-linear resistors. The resistance current is broken by the series-switch contacts. Fig. 9*b* shows a six-break circuit-breaker with a rotating series switch at one end. The interruptors are arranged in pairs in V-formation on the top of three hollow insulators. Voltage distribution between interruptors is achieved by built-in condenser insulators, and resistors are not fitted. Fig. 9*c* shows a six-break circuit-breaker arranged in two vertical three-unit columns with a double vertical series switch between them. The motors for operating the series switches are contained in the large metal compartments at the top of the main supporting insulators. The interruptors are shunted by linear resistors incorporating internal gaps to break the resistance current. These circuit-breakers are all continuously rated at 1200 amp and are capable of operating at voltages up to 320 kV.

Fig. 10 shows Swiss, Swedish and Russian constructions in service for the 380–420 kV class. Fig. 10*a* shows a 380 kV 8500 MVA 1000 amp 10-break circuit-breaker without an external series switch. Compressed air is admitted into the interruptors when the circuit-breaker trips and is sustained between the contacts as long as the breaker remains open. To close the breaker this air pressure is released to atmosphere. Voltage grading capacitors are arranged across each break, and voltage-limiting non-linear resistors with compressed-air resistor current interruptors are arranged at the uppermost level.

The contacts of the resistor current interruptors are normally open, but close rapidly when compressed air is let into the main breaks and remain closed so that the resistors are connected in parallel with the main breaks during the whole of the arcing period. A few half-cycles after final extinction of the arc the resistor contacts open and interrupt the resistor current. During a closing operation the resistor contacts remain in the open position.

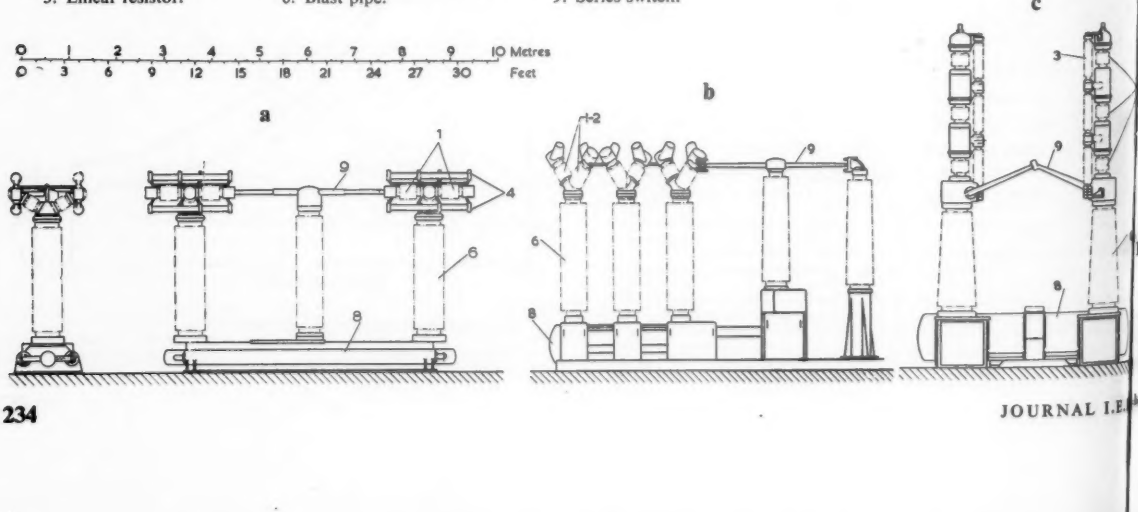
Fig. 10*b* shows a 380 kV 13000 MVA 1500 amp circuit-breaker which has twelve series-connected breaks and a series isolator which is used for permanent disconnection and for closing the circuit. The cylindrical breaking units are arranged in V-formation with two breaks in each leg, and three such V's are mounted on hollow insulators, this arrangement ensuring rapid and simultaneous operation of each break. Linear voltage grading resistors of high value are fitted across each break and a non-linear resistor spanning the complete circuit-breaker limits transient switching voltages. The current through both resistors is broken by the opening of the series switch. With high-speed auto-reclosing the series switch remains in the closed position during the first breaking operation.

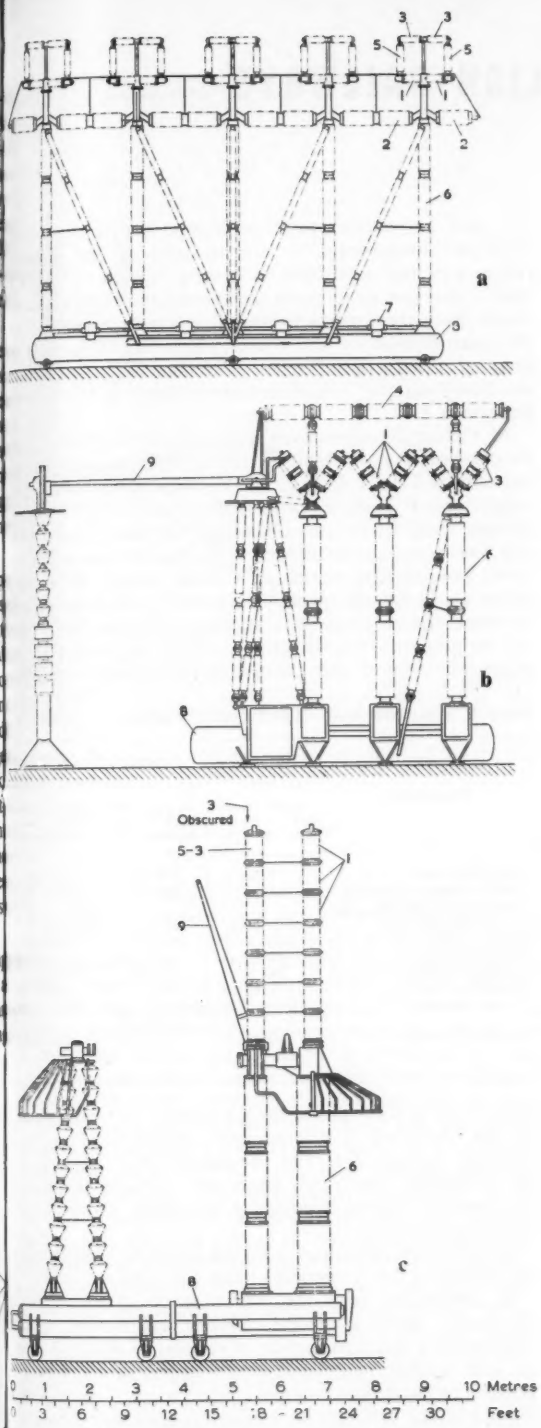
Fig. 10*c* shows a 400 kV 10000 MVA, 2000 amp seven-break vertically mounted circuit-breaker with a vertical-break series switch. In parallel with the columns of interruptors are columns of linear voltage-grading

9 *275/300 kV circuit-breakers in service in Britain*

The three drawings are to the same scale.

1. Interruptor.
2. Grading capacitor.
3. Linear resistor.
4. Non-linear resistor.
5. Resistor-current interruptor.
6. Blast pipe.
7. Blast valve.
8. Air receiver.
9. Series switch.





10 *380/400 kV circuit-breakers in service in Europe*

The three drawings are to the same scale.

1. Interruptor.
2. Grading capacitor.
3. Linear resistor.
4. Non-linear resistor.
5. Resistor-current interruptor.
6. Blast pipe.
7. Blast valve.
8. Air receiver.
9. Series switch.

resistors and switching resistors, all of wire-wound construction; the sequence switch interrupts the grading-resistor current, but the current through the low resistances is broken by an auxiliary break included in each resistor assembly.

Some earthed metal-enclosed constructions are being used at voltages up to 150 kV, and there are open-type dead-tank constructions in use in Canada for 115 kV and 138 kV. The compressed air and the interruptors of the latter are contained in the main circuit-breaker tank into which oil-filled bushings project. The interruptors are mounted on insulated exhaust tubes which project through the bottom of the tank and also carry the exhaust valves. The main advantages of this construction are the compact arrangement which may be handled and installed in a similar fashion to a bulk-oil circuit-breaker, and the current-transformer accommodation which is inherently available in the main bushings.

Future Development

There have been suggestions from time to time that the air-blast circuit-breaker may develop into a closed-circuit gas-blast device using gases such as carbon dioxide, hydrogen or sulphur hexafluoride as the extinguishing medium. While there are some technical advantages with these alternatives, present technique is confined to the use of air on economic grounds.

The main lines of development of air-blast circuit-breakers are likely to be towards simpler and more economic designs. If this is achieved the air-blast circuit-breaker will become widely accepted, with the consequent benefits of minimum maintenance and maximum availability for service without fire risk.

Summary

Load growth, the use of higher transmission voltages and increasing short-circuit powers necessitate continuous switchgear development. Air-blast circuit-breakers are generally favoured for very high voltages and large breaking capacities, but they often entail relatively high initial and running costs because of their relatively complex design and their consumption of large quantities of compressed air on each tripping operation. The trend is to combine the good performance, clean operation and durability of the air-blast circuit-breaker with greater economy and simplicity, thus enhancing its appeal.

Acknowledgments

The author wishes to thank the directors of A. Reyrolle and Co. for permission to publish this article, and various firms and organizations for the information and drawings supplied, in particular the following: A.E.G. Electric Co.; British Brown Boveri; Canadian Westinghouse Co.; Établissements Merlin and Gérin; Ferguson, Pailin; Fuller Electric; Metropolitan-Vickers Electrical Co.; English Electric Co.; and the U.S.S.R. Ministry of Power Stations. He also thanks his colleagues at A. Reyrolle and Co. for their assistance in the preparation of the article.

ELECTRIFICATION OF THE POLISH RAILWAYS

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In a lecture delivered before the Utilization Section on the 24th October 1957, Professor Podoski described the progress of electrification of the Polish railways since the first plans were drawn up some thirty years ago. It has been a chequered history, for much of the damage suffered in the Second World War has had to be made good, but the development is now gaining impetus once more. The article is a shortened version of the original lecture.

PROFESSOR JAN PODOSKI, MEMBER

THE first plans for the electrification of the Polish railways were made more than thirty years ago in connection with the modernization of the Warsaw railway junction, and, from the start, the 3000-volt d.c. system was proposed. In 1932 a contract was signed between the Polish Government and a group of British firms for the electrification of some 70 miles of suburban lines in the vicinity of Warsaw. The contract included the supply and erection of six traction substations, the electrification of about 160 miles of track, and the supply of six heavy and four light locomotives together with the electrical equipment for sixty 3-coach train units. The work was finished in 1938 and the whole system operated to the complete satisfaction of the Polish State Railways; it ameliorated the traffic conditions considerably and reduced the operating costs.

The details of the work and of the difficulties experienced were described in a paper published in Part II of the *Journal* in October 1948.*

The plant was badly damaged at the beginning of the war in 1939, recommissioned after a year, and totally destroyed during the Warsaw rising in 1944. What remained of the rolling stock was transferred by the Germans to the Reich. The rehabilitation began immediately after the end of hostilities, but only thirty-six units and one substation could be recovered. However, after five years of work all the lines were again in operation and in addition two more suburban sections were electrified. A large part of the new equipment was imported from Sweden, although a certain amount of equipment for the substations and motor-coach trains was supplied by the British contractors.

It may be noted that, although more than twenty years passed since the original supplies were delivered by the British firms, the main features of the rolling stock ordered after the war remained practically unchanged. The characteristics of the motor-coach units for suburban operation are given in Table 1.

Projects for the electrification of the three remaining suburban sections were ready when a more urgent problem arose in the extremely rapid growth of the traffic on one of the most important routes of the whole network—the 220-mile line connecting Warsaw with the Silesian coal basin—where the volume of traffic exceeded the carrying capacity of the line, and any further increase became impossible without important investments. As the capacity of the substitute routes was also exhausted, it became imperative either to build a new line or to equip the existing one with additional tracks. Both these solutions were found more expensive than the electrification of the route, which would increase the carrying capacity of the line by more than 50%. This solution was finally adopted. The electrification began in 1952 and was finished in 1957.

All the supplies came from East Germany and Sweden and the overhead line was built by the railway personnel. The line operates at 3000 volts d.c. and is supplied from seventeen substations. It is too early to speak of the results achieved, because some trains are still hauled by steam locomotives, and time-tables are established partly for the steam traction, which puts electric service at a disadvantage. However, it seems certain that the capacity of the line has been appreciably increased and an annual coal economy of some 300000 tons will be achieved. On the other hand, it seems that it was rather a mistake to open the electric service before the whole system was quite prepared for the change, as initial troubles on the electrified line were more numerous than could normally be expected. The personnel lacked training, and the equipment, which was taken over in haste and without due testing, proved inadequate in many instances with unfortunate results.

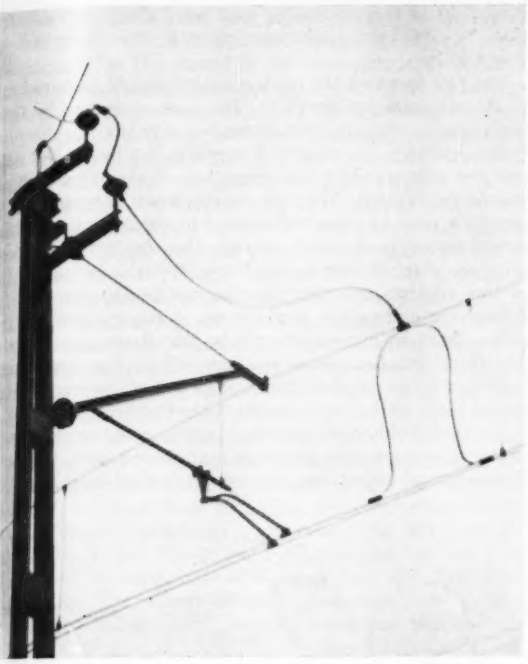
Table 1. Characteristics of motor-coach units

Composition	*British*	*Swedish*	*Polish*
	motor coach and two trailers articulated	driving trailer motor coach driving trailer	driving trailer motor coach driving trailer
Weight of unit	113 tons	118 tons	121 tons
Total number of seats ..	262	240	—
Maximum standing and seating capacity ..	over 500	568	600
1-hour rating	600 kW	664 kW	600 kW
Maximum speed ..	53 m.p.h.	62 m.p.h.	62 m.p.h.
Wheel diameter ..	39½ in.	39½ in.	39½ in.
Length of unit	195 ft	205 ft	205 ft
Type of control ..	Multiple, automatic, electrically driven camshaft		
Control voltage ..	110 volts	110 volts	110 volts

All the initial difficulties are being gradually eliminated and the electric service is operating more and more smoothly.

In connection with the electrification of this line an interesting detail is worth mentioning. Polish industry experiences a serious shortage of copper, of which there are no local sources in Poland. It was hoped that it would be possible to use steel-aluminium contact wires of special design instead of the ordinary hard-drawn copper wires. Extensive tests were made for over two years on trial sections equipped with steel-aluminium wires, but it was found that, although this wire is satisfactory on tramway and trolleybus routes, it is not altogether satisfactory for use in main-line electrification. If the steel-aluminium wire is hung over a line on which the traffic is not sufficiently heavy, it corrodes rapidly; on the

* Podoski, J.: 'The Electrification of the Warsaw Railway Junction', *Journal I.E.E.*, 1948, 95, Part II, p. 505.



1 *Arcing horns for the protection of the 3000-volt d.c. overhead line*

other hand, the contact surface becomes easily pitted if the current collected exceeds some 600–700 amp. Consequently, these wires cannot be used on lines on which heavy locomotives are expected to operate, and their application is therefore limited to some suburban sections with sufficiently heavy traffic but without locomotive service.

Another interesting experiment was made in connection with protection against voltage surges. It is well known that the operation of lightning arresters is far from satisfactory and that they are often the cause of serious troubles. Arcing-horn protection was considered obsolete and was superseded long ago by condenser or cathode-type arresters, which were believed to be more reliable. Polish State Railways are now experimenting again with arcing-horn protection in its simplest form, i.e. without earthing resistance or arc-blowing coils. The only essential change is in the dimensions of the horns, which are several times bigger than in the old models. The horns are made of ordinary contact wire and have a gap of 10 mm, corresponding to a flashing voltage of 6 kV. Many tests confirmed that an arc is extinguished on these horns within 500 millisec, the only condition being that there must be a clearance of at least 12 ft above the horns.

A 20-mile section equipped with three arresters of this type per track-mile and mounted on top of the traction masts has not had a single breakdown caused by lightning surges for over two years, whereas, before the fitting of the horns, breakdowns were particularly frequent on this section during summer months. Although it would be premature to give any final opinion in this respect, it seems worth while to draw expert attention to this simple and inexpensive device.

Apart from the Warsaw–Silesia electrification, two more recent schemes should be mentioned. The first is an inter-urban line connecting three ports on the Baltic Sea coast—Gdansk, Sopot and Gdynia—which have a total population of over 400 000. The rolling stock for this line came from reparations, and it has been necessary, therefore, to use a supply voltage of 800 volts d.c., for which these units were built. The substation equipments were of British manufacture. The opening of an inter-urban electric service with fast trains every ten minutes caused important changes in the whole life of the three cities. Within five years the traffic on the line reached the average of 150 000 passengers daily, which is more than the number of passengers transported by the trams, trolleybuses and omnibuses in the three towns. The limit capacity of the line has now been reached, and large extensions of the scheme must be envisaged.

Another scheme worth mentioning is the network of railway lines carrying sand used for filling empty shafts at several coal mines in Upper Silesia. Although coal lies in that district at a depth of 1 000 ft or more, the structure of the ground is such that sinking occurs if an empty shaft is not filled in.

About 25 miles from the coal district there is an area of thousands of acres of sand dunes of glacial origin. The Ministry of Mines have built a network of railway lines connecting this area with various coal mines. Special wagons of 60 tons capacity are being automatically loaded with sand, assembled in twenty-four wagon trains weighing 1 900 tons and sent to the mines. Since the gradients on the lines approach 1·5/100, extremely heavy locomotives are required, and no steam locomotive of the types employed in Poland could haul such trains at the required speed. When the system is in full operation 172 pairs of trains daily will carry a total of 800 000 cubic feet of sand to the pits. The lines operate now at about 50% of their maximum capacity. About 60 miles of track are now electrically operated at 3 000 volts d.c. The 120-ton locomotives built on a British licence and supplied with British electrical equipment are of the $C_0 + C_0$ type and have a one-hour rating of 1 500 kW, a draw-bar pull of 30 tons and a maximum speed of 40 m.p.h. They have a double set of current collectors to enable them to operate both on ordinary overhead lines and on temporary lines with contact wires mounted at the side of the tracks on poles

2 *3000-volt d.c. locomotive type $C_0 + C_0$ with a coal train*

fixed to the sleepers. The locomotives are of especially robust design suitable for operation on temporary tracks and dust-proof to prevent the ingress of sand into the body.

Future Programme

Due consideration has been given lately to the possibilities of the single-phase system at the standard frequency of 50 c/s, and the decision of British Railways to adopt this system was widely discussed. This decision came after the publication by Russia of an electrification programme in which it is proposed to electrify several routes at 25 kV a.c. without, however, converting the lines already electrified at 3000 volts d.c. It is expected that the length of the lines to be electrified in Russia at 50 c/s will amount at the end of the next five-year plan to 12% of the length of all electrified sections.

A group of experts appointed by Polish State Railways studied the whole matter in detail and came to the conclusion that the electrification of the Polish railways should be continued at 3000 volts d.c. The undoubted merits of the 50 c/s system cannot be used to full advantage in Polish conditions, where the distances are not very great, the hauled weight of the trains does not exceed 2500 tons, and there is a large proportion of suburban traffic. It was decided, therefore, that it would be a mistake to abandon a well-tried system in the hope of achieving economies which would not exceed at the best a small fraction of the capital cost of the electrification and even less in maintenance. In addition, it was stressed that the Polish electrical industry is not sufficiently developed to change over, without serious difficulties, from one system to another, and even less to undertake at present the simultaneous production of two types of equipment.

Nevertheless, the future application of the a.c. system was not totally ruled out of the electrification plans. Three districts proposed for electrification in the second phase have been selected as most suitable for electrification at 50 c/s, and it was proposed to examine again whether the new system would be economically justifiable for these lines. In that event, the single-phase system would operate simultaneously with the existing 3000 volts d.c. and would extend over 23–26% of all the electrified network. The equipping of a trial section for 50 c/s operation is also envisaged.

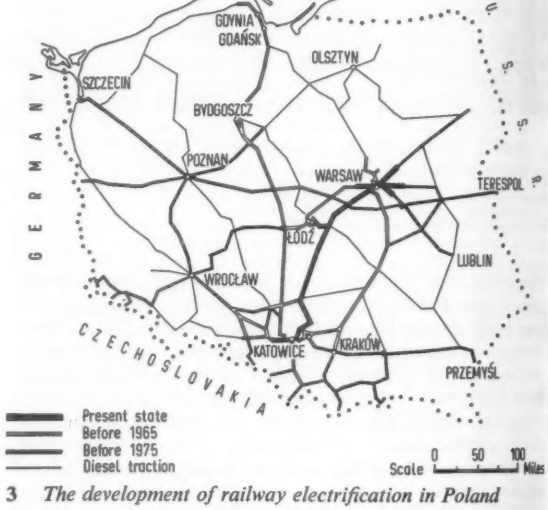
The question of the system of supply is by no means the most important problem facing the Polish State Railways. They must decide first of all upon the general outlines of the modernization scheme for the whole network. In this respect the decision taken earlier this year by the executive not to order any more new steam locomotives seems to be of fundamental importance. It shows that steam traction must gradually disappear from the Polish railways, and as the only systems which can at present take its place are electric, Diesel or gas-turbine traction, the railway administration will have to decide how these systems should co-operate and also which lines should be temporarily left to steam traction. No final decision has yet been taken in this respect and only preliminary studies are ready.

The present paper refers only to electrification, although the problem of the application of internal-combustion engines is by no means less important.

It is clear from preliminary calculations that the electrification of not less than 3300 miles of route would be unquestionably justified, although some experts believe that this figure should be doubled. Of these 3300 miles, about 400 are already electrically operated. The average traffic density on the lines foreseen for electrification amounts at present to 19 million trailing tons per annum. It is expected that by 1965 the traffic density will have increased by about 40%.

The rate at which the electric service should be introduced is by no means unimportant. This rate is limited by three main factors, namely the limited production capacity of Polish industry, the restricted number of fully trained staff, and the rate at which the relegation of steam locomotives should be effected. The full electrification programme will require a total of some 600 electric locomotives and slightly more motor-coach train units. The present productive capacity of the Polish locomotive industry is practically *nil* in this respect, but the first locomotives totally built in Poland are undergoing service tests. Assuming that no new orders for steam locomotives will be placed, one can conclude that the Polish locomotive industry will be forced to adjust itself to the new requirements and in five or six years will be able to cover all the requirements of the Polish State Railways.

The staff problem is particularly acute, as the wages offered on the railway are generally lower than those paid by industry. The system of wages does not encourage workers to improve



3 *The development of railway electrification in Poland*

their professional qualifications, and there is a large-scale turnover of labour which is extremely detrimental in electric traction, where professional qualifications are particularly important.

As regards the elimination of old steam locomotives, this matter must receive careful consideration. Although the locomotive stock of the Polish railways is antiquated (45% of all the locomotives being more than twenty-five years old and only 20% having been built less than twelve years ago), it seems that it would not be economic to scrap more than 250 engines per annum, because if a larger proportion were condemned the length of their service would be unduly shortened. Eighty to a hundred electric locomotives and/or motor coaches are the equivalent of this figure, and, if unnecessary condemnation of the steam locomotive stock is not to take place, no more electric locomotives and motor coaches should be commissioned each year.

Taking all these facts into consideration, it would be reasonable not to make excessive claims for a very rapid electrification, as this would be not only technically difficult, but also not advisable economically. It seems that an average of about 150 route-miles electrified per year would be the optimum figure in these conditions. Since during the last five years only 70 miles per year have been converted to electric traction, this target will not be easy to achieve. On the assumption that 150 miles would be electrified every year, the conversion to electric service of 3 000 miles would require some twenty years, and the electrification plans should be established for that period, independently of the conversion of part of the lines to internal-combustion traction.

During the first part of this period, until 1966, the full electrification of the Warsaw and Lódź districts should be completed, and in addition a large proportion of the Upper Silesian network should be converted to electric service. This network consists of more than 600 miles of routes with passenger service in an area not exceeding 1 000 square miles. Further, the main lines between the Upper Silesian area and Wroclaw and the seaport of Gdynia should be electrified. Katowice, the main town of Silesia, will become an electric-traction centre equivalent to Warsaw. The electrification programme for the first decade comprises also the lines from Warsaw to Poznan and to Krakow and the line from Krakow to Katowice. Detailed plans are now nearing completion, and on some sections work has already been started.

The programme for the second decade is less definite. It is certain that the rest of the Silesian district will be electrified, and that the electrification of several railway sections in the Western and Southern hills will be completed. Poznan will become the third important electrification centre of the system. It is possible that a part of this programme will utilize the single-phase 50 c/s system.

It is interesting to consider what proportion of the total mileage it is expected to electrify. The figures, according to existing estimates, are given in Table 2.

Table 2. Anticipated development of electrified railways

	1956	1965	1975
Electrified route miles ..	375	1 800	3 250
Percentage of the total mileage	2·5%	12·5%	23·0%
Percentage of trailing ton-miles on electrified sections	7%	50%	70%

The trailing ton-miles on the electrified lines will reach 55×10^9 in 1965 and 92×10^9 in 1975. This means that the average traffic density on the electrified sections will be respectively 31·5 and 28 million trailing ton-miles per mile in 1965 and 1975. These remarkably high figures prove how necessary is electrification for such heavy traffic routes.

According to preliminary estimates, the total cost of the electrification scheme, including work already done, will amount to roughly £225 million. The expected economies on fuel alone, disregarding other important sources of economy, will amount after the electrification programme is concluded to approximately 5 million tons of standard coal per annum. This means that the fuel economies alone would cover the cost of the electrification in about ten years.

In 1956, 90% of the electrified traffic consisted of passenger trains, and the average unit consumption amounted to 68 Wh per trailing ton-mile. With the increase of the proportion of goods trains the unit consumption will be gradually reduced and it is expected that by 1965 it will become 38 Wh per ton-mile and by 1975 even 34 Wh per ton-mile. The total annual demand for all the electrified lines can be estimated at 2 150 million kWh in 1965 and 3 700 million kWh in 1975.

Co-operation of Foreign Industry

The potential of the Polish electrical industry is at present limited. Traction motors of 3 000 volts are produced, but in insufficient numbers, high-speed circuit-breakers require improvements, the manufacture of h.v. mercury-arc rectifiers has only just started, and the factories lack experience in the production of traction control equipment. Therefore, if the programme of electrification established by the authorities is to be fulfilled, it is essential to obtain foreign supplies in the first period of large-scale electrification, since Polish industry will not be able to cope with the increasing demand for equipment. It is difficult to specify what the amount of this deficiency will be, but it is the author's opinion that, in the first period, between one-half and two-thirds of the electrification material will have to be ordered abroad.

As mentioned before, the electrification of every mile of railway line frees a considerable tonnage of coal, which can pay for the costs of electrification within ten years. The British electrical industry has an excellent reputation in Poland. On some suburban lines British substations and British rolling stock delivered over thirty years ago are still in full working order and on the Warsaw railway junction the British equipment supplied in 1936 is considered to be the most reliable and efficient of all.

It can be said that in these conditions there are certainly most interesting prospects for the British electrical industry in Poland, although it seems that this favourable position will not last for more than five to ten years, that is, until the Polish electrical industry develops sufficiently to cope with the programme proposed.

CORRESPONDENCE

THE ELECTRIC RAILWAY SOCIETY

From B. J. PRIGMORE, M.A., M.SC., ASSOCIATE MEMBER*

The Electric Railway Society Committee was very appreciative of the notice given to the Society in the February *Journal*. The group of inquiries which followed it has been most heartening, and we hope it may result in an increase in the proportion of the technically knowledgeable amongst our members. Then, even more, can it become our claim to be discriminating students of, rather than merely young enthusiasts for, our subject.

I thank you for your goodwill towards us.

* Mr. Prigmore is a lecturer in Electrical Engineering at the Imperial College of Science and Technology, University of London, and is Honorary Chairman of the Electric Railway Society.

SPEECHES AT THE ANNUAL DINNER

Mr. Goldup presides over a distinguished gathering of members of The Institution and their guests

As is customary, the Annual Dinner of The Institution was held at Grosvenor House at the end of February, the date this year being the 27th. Some 1450 members and guests sat down to dinner. The President, Mr. T. E. Goldup, was in the chair.

Among those present were:

His Excellency Herr Hans von Herwarth (*Ambassador for the Federal Republic of Germany*); Monsieur G. Libersart, L.H. (*Plenipotentiary Minister and Commercial Counsellor to the French Embassy*); His Excellency Mr. E. Asafu Adjaye (*High Commissioner for Ghana*); S. M. Khan (*Deputy High Commissioner for Pakistan*); His Excellency Mr. J. A. Malik (*Ambassador for the Soviet Union*); His Excellency Monsieur A. Daeniker (*Ambassador for Switzerland*); The Rt. Hon. The Viscount Falmouth (*Honorary Treasurer*); The Rt. Hon. The Viscount Simon, C.M.G. (*Chairman, Port of London Authority*); The Rt. Hon. Lord Adrian, O.M., M.D., F.R.S. (*Master of Trinity College; Vice-Chancellor, University of Cambridge*); The Rt. Hon. Lord Citrine, K.B.E., LL.D.; The Rt. Hon. Lord Hives, C.H., M.B.E., D.SC., LL.D. (*Chairman, National Council for Awards in Technology*); The Rt. Hon. Lord Mills, K.B.E. (*Minister of Power*); Sir George H. Nelson, BART. 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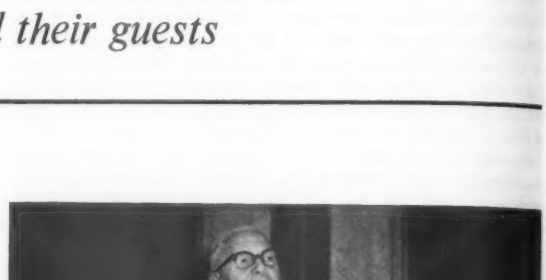
(*Permanent Secretary, Ministry of Supply*); Sir Harry Pilkington (*Chairman, National Advisory Council on Education for Industry and Commerce*); Sir Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.) (*Immediate Past-President; Faraday Medallist, 1958; Director-General, Post Office; President, The British Electrical and Allied Industries Research Association*); Sir Harry Railing, D.ENG. (*Past-President, Honorary Member*); Admiral Sir Peter Reid, K.C.B., C.V.O. (*Third Sea Lord and Controller*); Sir Henry Self, K.C.B., K.C.M.G., K.B.E. (*Chairman, The Electricity Council*); Sir Owen Wansbrough-Jones, K.B.E., C.B. (*Chief Scientist, Ministry of Supply*); Sir Arthur Whitaker, K.C.B., M.ENG. (*President, The Institution of Civil Engineers*); Sir Reginald Wilson (*President, The Institute of Transport*); J. R. Beard, C.B.E., M.SC. (*Past-President; Honorary Member*); E. Bolton, B.SC.TECH. (*Hon. Secretary, North Staffordshire Sub-Centre*); E. A. Bromfield (*General Secretary, The Association of Supervising Electrical Engineers*); R. Bruce, M.SC. (*Hon. Secretary, North-Western Centre*); J. S. A. Bunting, M.C. (*Chairman, The Cable Makers' Association*); H. A. Carr (*Hon. Secretary, North Midland Centre*); Dr. R. Cockburn, C.B., O.B.E., M.SC.; A. Cooper (*Surveyor of Lands, Duchy of Lancaster*); E. H. Cox (*Hon. Secretary, South Midland Centre*); F. Day (*Hon. Secretary, North Lancashire Sub-Centre*); G. B. Devey (*Hon. Secretary, South-Western Sub-Centre*); J. H. P. de Villiers (*Hon. Secretary, Scottish Centre*); Dr. R. S. Dietz (*Deputy Scientific Director, Office of Naval Research, American Embassy*); B. Donkin, B.A. (*Member of Council; Chairman, The Association of Consulting Engineers*); Capt. (S) A. D. Duckworth, R.N.(RETD.) (*Secretary, The Institution of Naval Architects*); Dr. P. Dunsheath, C.B.E., M.A., D.SC.(ENG.) (*Past-President*); Professor R. S. Edwards; R. L. H. Ewin (*President, Society of X-Ray Technology*); J. S. Forrest, D.SC., M.A. (*Member of Council*); F. F. Freeling (*Hon. Secretary, Western Centre*); P. W. R. Gatliff, B.SC. (*Hon. Assistant Secretary, North Staffordshire Sub-Centre*); S. E. Goodall, M.SC.(ENG.) (*Vice-President*); P. Goudime (*President, The Scientific Instrument Manufacturers' Association*); D. W. Gregory (*Hon. Secretary, South-West Scotland Sub-Centre*); E. S. Hall (*Hon. Secretary, Rugby Sub-Centre*); H. L. Haslegrave, M.A., PH.D., M.SC.(ENG.) (*Past Chairman, East Midland Centre*); K. Headlam-Morley (*Secretary, The Iron and Steel Institute*); Capt. N. Hiller, B.SC.(ENG.) (*Hon. Secretary, East Anglian Sub-Centre*); Professor W. V. D. Hodge, F.R.S. (*Secretary, The Royal Society*); H. T. Hough (*President, The Institution of Municipal Engineers*); H. W. Housley (*Hon. Secretary, Southern Centre*); Wilfrid Jackson, D.SC., D.PHIL., DR.SC.TECH., F.R.S. (*Vice-President*); J. G. Knowles, M.A. (*Chairman, The British Electrical and Allied Manufacturers' Association*); Colonel B. H. Leeson, C.B.E., T.D. (*Past-President*); E. Leete (*Honorary Member*); W. E. Lewis, B.SC.(ENG.), PH.D. (*Hon. Secretary, West Wales (Swansea) Sub-Centre*); Dr. R. W. Linstead, C.B.E., F.R.S. (*Rector, Imperial College of Science and Technology*); Major-General C. Lloyd, C.B., C.B.E., B.SC. (*Director, Department of Technology, City and Guilds of London Institute*); Dr. J. F. Lockwood, M.A. (*Vice-Chancellor, The University of London*); H. A.



The President speaks at The Institution's Annual Dinner with Mr. Malik on his left and Lord Adrian on his right

Longden, B.SC.(ENG.) (*President, The Institution of Mining Engineers*); G. S. C. Lucas, O.B.E. (*Vice-President*); T. M. McCammont (*Hon. Secretary, North Scotland Sub-Centre*); J. McKeever, B.SC.(ENG.) (*Hon. Secretary, Irish Branch*); F. C. McLean, C.B.E., B.SC. (*Member of Council*); H. McNeil, B.E. (*President, The Institute of Fuel*); J. S. McPetrie, PH.D., D.SC. (*Chairman, Radio and Telecommunication Section*); T. Makin (*Chairman, Mersey and North Wales Centre*); Dr. J. G. Malloch, M.B.E. (*Scientific Attaché, representing the High Commissioner for Canada*); C. T. Melling, C.B.E., M.SC.TECH. (*Vice-President*); Professor E. B. Moullin, M.A., SC.D. (*Past-President*); J. Muil (*Registrar and Secretary, The Professional Engineers Appointments Bureau*); A. A. Part, M.B.E. (*Under Secretary, Ministry of Education*); Rear-Admiral K. H. T. Peard, C.B.E. (*Director, Naval Electrical Department*); H. S. Petch, B.SC.(ENG.) (*Chairman, Measurement and Control Section*); J. D. Pierce (*Chairman, East Midland Centre*); B. G. Robbins, M.SC.(ENG.) (*Secretary, The Institution of Mechanical Engineers*); E. B. Sawyer (*President, The Illuminating Engineering Society*); Professor M. G. Say, PH.D., M.SC. (*Chairman, Supply Section*); R. Somerville, C.V.O. (*Clerk of the Council, Duchy of Lancaster*); C. E. Strong, O.B.E., B.A., B.A.I. (*Member of Council*); J. Sykes (*Hon. Secretary, Sheffield Sub-Centre*); G. I. Thomas, B.SC. (*Hon. Secretary, South-East Scotland Sub-Centre*); S. Towill, B.SC.(ENG.) (*Hon. Secretary, Mersey and North Wales Centre*); Professor W. Wardlaw, C.B.E., D.SC. (*President, The Royal Institute of Chemistry*); H. S. Wathes (*President, The Electrical Contractors' Association*); Dr. H. F. Willis, M.SC. (*Chief of the Royal Naval Scientific Service*); A. W. Woodbridge, M.SC. (*President, The Institution of Railway Signal Engineers*); J. F. Wright (*Chairman, Western Centre*); I. D. Yeaman (*President, The Law Society*); H. T. Young (*Past-President; Honorary Member, 1958*); and W. K. Brasher, C.B.E., M.A. (*Secretary*).

The dinner began with grace, said by the Very Reverend A. C. Don.

After the Loyal Toasts had been proposed by the President and duly honoured, he called the attention of the company to the impending centenary of the senior Past-President of The Institution. Mr. Goldup said: 'To-morrow, the 28th February, a Past-President of The Institution celebrates his one hundredth birthday. As you know, he is Sir James Swinburne, Fellow of the Royal Society, who was President of this Institution in the year 1902. He became a member of The Institution in 1885.

'The Council at their last meeting decided on the occasion of Sir James's birthday to send him a congratulatory letter from the Council and from this gathering here this evening. Arrangements have been made for this message, which has been signed by me, to be taken personally to Sir James by Dr. Eccles, also a Fellow of the Royal Society. Dr. Eccles was the President of The Institution in 1922.'

Sir Gordon Radley welcomes Sir George Edwards

The President then proposed the health of Sir James.

[As most members know, Sir James Swinburne died about a month after his hundredth birthday. An obituary notice appears on p. 269.]

Lord Adrian then rose to propose the toast of 'The Institution of Electrical Engineers'. He said:

'It was a great compliment to have your tactful letter reminding me that I had accepted your invitation to this dinner, and hinting that I might feel moved to propose the health of The Institution. But your letter came when I was recovering from Asiatic influenza, and so I was taking a rather gloomy view of the world. There were no good detective stories to read, the radio had nothing but parlour games or lessons in Spanish, I could not taste anything, and in the particular phase of the complaint that I was then in the thought of a dinner on this scale brought me out into a strong perspiration. I tried to feel that The Institution was probably doing its best and deserved to have its health drunk, but I could only picture electrical engineers building power stations in beauty spots and hiding the suburbs with television aerials. I thought that I might find something to quote out of the poem which Hilaire Belloc wrote a long time ago entitled "The Benefits of the Electric Light", but I could remember only two lines and somehow they did not seem really suitable. They were:

> Observe the electrician where he stands
> Soot, oil and verdigris on his hands.

'However in the state that I was in when I had your letter I had not the will-power to refuse, and now I am very glad that I did not. Although I cannot believe that electrical engineers need to be spurred on by after-dinner speeches, I can now look on the bright side and say how grateful we all are for the work that The Institution is doing, and how much we want it to prosper in its undertakings. Life would be far bleaker, even at the South Pole, without the science and arts which The Institution looks after. We realize the heavy responsibilities you have to shoulder in looking after them on an adequate scale.

'I think that one of the most impressive sights that they have in that most impressive city of Moscow—and Mr. Malik will correct me if there is something more impressive—is the range of rooms in the Kremlin where Lenin lived, which corresponds to No. 10 Downing Street. There are maps on the walls which show his plans for the large-scale electrification of Russia. He believed that they could not have material progress without more electricity, and we can see the result now. In fact, if we look up in the skies through radio telescopes we can no doubt see two of the results circulating round the world.

'Of course, we have had a longer start and a smaller country to cover, but we and every country are finding more need for electricity ever year and that means more

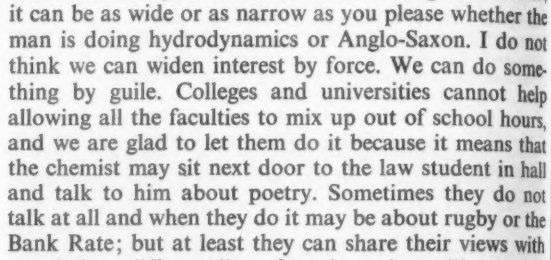
highly trained people in every grade—more technicians, more technologists, more research workers and more people to teach them. Looking round this room to-night one may think that there are quite a number already, but it is no reflection on Grosvenor House or on your hospitality to say that we should regard the health of The Institution as being more robust if it could have had twice as large a dinner to-night. Of course, the country would be in a healthier state if it could have twice as many people highly trained in many other technologies besides that of electricity; but everyone realizes that it is you who keep the world turning. We do not need more of you in this country merely to keep up with the Joneses. We want you very badly to help us pay the interest on our overdrafts.

'In fact we want more technologists and more scientists so badly that it is really time that we stopped declaiming about it and began to help you get more trained students for electrical engineering. Those of us concerned with education are trying our best to do that, but we too have our special difficulties, and I am afraid we are all expecting that the other places can increase their output much more easily than we can. At Cambridge, for instance, we can scarcely take more students until someone starts more colleges to put them in. The present colleges are filled to bursting, and they would lose their functions if they grew larger. But most universities are building as hard as they can, and industry is giving new science laboratories to schools; yet in spite of that, we are in danger of falling further and further behind our neighbours. They are trying to keep up with one another and they seem to have very much more money to spend on doing it.

'We are doing our best, but I think that we in the universities and all those concerned are being rather too timid about getting what we want. It is not that technology does not stand high enough in the academic scale. What seems to trouble some of us now is the feeling that it ought not to stand alone; that all science and no arts will make Jack a dull boy. We are frightened as you are also by the thought of hordes of young men and women trained from the cradle to be nothing but specialists, unable to think in terms of anything but symbols.

'I am sure we need not take this too seriously. We are tempted to do so because there are some of us who were at school a long time ago and have not quite grown out of it. Most headmasters then went on the theory that Latin prose and compulsory games were the best training for a successful career in almost anything. No doubt it did us good to be taught to work hard on very unrewarding problems; but it has left us with the belief that training in science and nothing else cannot be expected to turn out the sort of cultured and completely wise people that we have all become ourselves. It may be a comfort to think that, but I am sure that the headmasters and science masters of these days are doing their best to prove us wrong. Even in the forms where they specialize entirely in science they turn out boys who are much more civilized products than we ever were.

'No doubt it is an excellent thing to let engineers and everyone else attend the sort of special courses that we ought all to have attended ourselves, in social psychology, world government, the fine arts, and so on; and, of course, if we could give all the technologists another year at the universities and then several in industry, it would be so much better for their culture as well as their science. But personally I have never found that the subject a man takes makes very much difference to his range of interests; it can be as wide or as narrow as you please whether the man is doing hydrodynamics or Anglo-Saxon. I do not think we can widen interest by force. We can do something by guile. Colleges and universities cannot help allowing all the faculties to mix up out of school hours, and we are glad to let them do it because it means that the chemist may sit next door to the law student in hall and talk to him about poetry. Sometimes they do not talk at all and when they do it may be about rugby or the Bank Rate; but at least they can share their views with people in a different line of work so they will not seem quite so odd when they get out into an industrial concern. That seems to me the best sort of training that a university can give. It is the best way of keeping these students healthy and wise—and they are likely to be wealthy if they are to be electrical engineers. If there is



The German Ambassador, The Swiss Ambassador, Lord Adrian, Sir George Edwards, and Mr. Goldup

room to take them, I am sure we can turn them out in greater numbers without worrying unduly about their cultural background.

'What worries many of us much more is the background of students in the faculties which do not touch on science and technology. If some arts students are going to be our leaders, it will be a good thing for them if they have more scientists to talk to. If they are concerned with fundamentals they can talk to the cosmologists, and if they are to be lawyers or politicians they can talk to the psychiatrists, and if they have any feeling at all for human construction they can talk to the engineers. After all, you and your civil and mechanical

colleagues have constructed our modern world, and you are the people to show us what human skill can do. I can look at an abstract painting with as much enjoyment as most people, but how much rather would I look at the wiring diagram of my car in the instruction book. It excites the same sort of aesthetic wonder, but to me at least there is a feeling of hidden purpose about it. It may not help me to find out why the wind-screen wiper will not work, but at least it shows what modern technology has achieved. The design of every detail must be the result of fifty years' progress in scientific research, in discovering new materials, new ways of manufacture and so on. One could go further and say it points a lesson in what can be done by international give and take. It will be a sad day for us as a scientific nation if that diagram disappears from the instruction book as the ammeter is disappearing from the instrument board.

'I will only say this, that you will have to be very careful that we do not take your achievements for granted simply because they work very smoothly and nothing ever goes wrong. They are of value not merely to restore our credit in the exchange market, but to keep up our reputation for applied science. Everyone—lawyers, politicians and artists—ought to know something about what electrical engineering has done, and ought to have at least a general appreciation of the ideas that there are at the back of it. We are moving slowly in that direction; perhaps too slowly for our well-being. But I hope that you will not doubt our conviction that we must move as fast as we can. We are proud of our electrical engineers. We wish there were more like them, and we hope there will be very soon.

'I call on the company to drink to the very good health of The Institution of Electrical Engineers.'

The President, in response to Lord Adrian, said:

'Might I just pause at this stage to mention the ladies. There are four here this evening—three Corporate Members and one Graduate. I am sure they feel very safe indeed among this vast concourse of engineers. Nevertheless they are here in their capacity as engineers, and I am sure that I am voicing your wishes when I say to them 'A very hearty welcome to this, the Annual Dinner of our great Institution'.

'Sir Gordon Radley last year likened the President's position at the Annual Dinner to being at the end of a damped oscillation. He said you start as a Vice-President and at the Annual Dinner you sit at the remote end of the top table. Then as the years go by you oscillate backwards and forwards until you come to the centre as President. Then, he said, the President finds that he has the task of replying to the toast of The Institution of Electrical Engineers. I feel, Sir Gordon, that you may agree with me that this rather elegant analogy of yours requires bringing up to date; is it not a fact that I happen to be the first President of The Institution who has presided at the Annual Dinner with the added attraction that over him there are one or two satellites in orbit. So can we not liken the future Presidents of The Institution to being, as it were, shot off into outer space of Institution activity in the first year of their Vice-Presidency, and placed on a given orbit, controlled and monitored carefully by the permanent staff of The Institution. Then they are watched by the Council until the time arrives when the Council feel that they have had enough of orbiting around this great Institution, and decide to bring them back to the centre. Being good engineers and scientists they can manage to do this without raising the temperature of the Vice-Presidents too much and completely disintegrating them before they arrive where I am standing this evening.

'I am here to respond to the toast which has been so delightfully proposed this evening by Lord Adrian. In his speech he has given us a good deal of food for thought. Let us remind ourselves about this because we are in danger at times of not realizing the real significance of electrical engineers in this modern world.

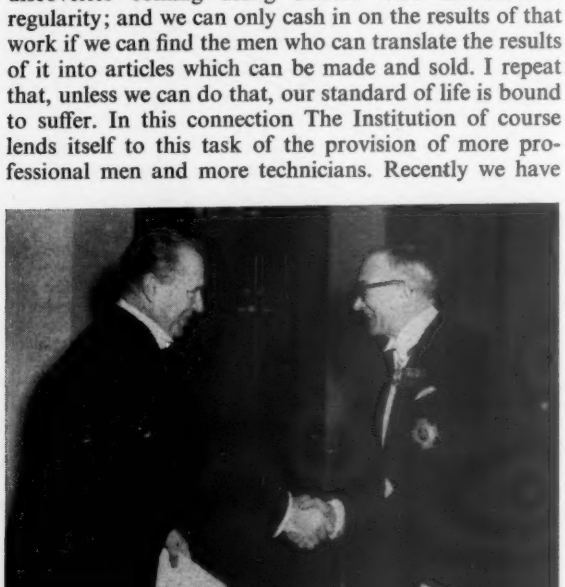
Col. Leeson, Dean Don, and Sir John Cockcroft enjoy a chat before dinner

'Lord Adrian said we had built the modern world together with our colleagues in the Civils and Mechanicals. That is quite true; just look at our Institution's activities as they are to-day, with our membership at 42 000 and with our specialized sections—Supply, Utilization, Measurement and Control and last, but not least, Radio and Telecommunication; and who knows what the future of radio and telecommunication as a Section of The Institution will be as the years go on. We have only to listen to the Chairmen of that Section blowing their trumpets about the number of papers which the Section produces each year in comparison with others! But you must take no notice of that. I think that that probably is the natural order of things to-day, with all due respect to the other Sections, which, I may add here and now, do a very good job of work for The Institution.

'Lord Adrian has mentioned shortages, and here we are back on our own familiar ground, although all of us in The Institution realize the importance of it, namely the acute shortage of craftsmen, technicians and professional men. As I have said in other places, at the Centres and

Sub-Centres, unless we can solve this problem the result will be that we shall find difficulty in maintaining the standard of life that we now enjoy. In fact it may go down.

'Look where you will and you will find scientific discoveries coming along almost with monotonous regularity; and we can only cash in on the results of that work if we can find the men who can translate the results of it into articles which can be made and sold. I repeat that, unless we can do that, our standard of life is bound to suffer. In this connection The Institution of course lends itself to this task of the provision of more professional men and more technicians. Recently we have had under discussion with the Ministry of Education some steps that we hope we shall be able to take that will at least be a contribution, and here I am going to tread on rather carefully prepared ground. In order that what I say can be recorded correctly and that the wrong interpretation may be avoided, with your permission I am going to read an agreed announcement drawn up by ourselves and the Minister:



The Russian Ambassador is greeted on arrival by the Immediate Past-President

Very much has been said and written about our grave shortage of technological manpower, but this is so vital a problem that I make no excuse for referring to it this evening. An important aspect of this problem (to which much too little attention has been given in the past) has been the absence of reliable estimates of the numbers involved, but from now on our statistics must be compiled carefully and regularly and I believe we shall reap much benefit from the painstaking work put in by Sir Solly Zuckerman and his Committee.

During the last five years steps have been taken which were about a generation overdue, and we must ask ourselves whether these appear adequate. We commend the expansion of university education with the support of the University Grants Committee and welcome the recent announcement of a £60 million programme for further expansion. When details of this programme are being worked out I hope it will be borne in mind that in electrical engineering the estimates of the manpower we shall need in 1970 are in fact more likely to represent estimates of our requirements some four or five years earlier.

Our Council welcomed the first Report of the Hives Council, which by encouraging and supporting selected colleges is enabling these colleges to produce a new group of technologically qualified electrical engineers. It is specially pleasing that the first Diploma in Technology will be awarded this summer and, I think, significant that it will be in electrical engineering.

Technical colleges have been quick to realize the importance of the new form of sandwich courses, and many such courses have been designed. As a result, there has been a considerable variation in standards, and in addition the relationship between the various full-time and part-time courses has tended to become confused. This problem has been the subject of recent discussions between The Institution and the Ministry of Education, and I am happy to have the Minister's approval to tell you that a joint statement will soon be issued. A main feature of the new pattern will be a two-year sandwich diploma course for technicians to follow the Ordinary National Certificate. In future the Ordinary National Certificate may lead either to one of these new technician's courses or to a Higher National Certificate, a Higher National Diploma, or a Hives course. Apart from the universities it will be mainly the Hives and the Higher National Diploma course to which we shall look for our future professional members, although I want to make it quite clear that the Higher National Certificate will still provide an avenue, but an increasingly laborious one, to professional qualification. I personally feel that this part-time method of progressing towards professional status is not always in the best interest of the student, particularly in view of the wider and deeper field that now must of necessity be covered.

I cannot leave this rather brief outline of some of the information to be given in the joint statement, which I hope and believe industry and the technical colleges will welcome when they receive it, without commenting on the happy and co-operative spirit that prevails today in discussions between senior officers of the Ministry and our Education Committee.

'I think you will agree with me that that is a positive and active step forward that we in The Institution are taking. I cannot help myself stressing this problem from the point of view of the manufacturer. Many of us sitting here to-night who are responsible for the electrical manufacturing industry in this country know only too well what we could achieve with just a few more professional men, technicians and craftsmen. I repeat that if we do not find the means of achieving this and relieving this acute shortage, we shall not be able to withstand the competition that is bound to come from countries oversea.

'In the commercial field of world competition there is, as I see it, bound to be a huge technological battle in which the laboratories, design offices and the factories manned by technical personnel of all grades will be in the front line, our reserves consisting of the schools, colleges and universities manned by students, schoolboys and also schoolgirls. To-morrow, together with the President of The Institution of Civil Engineers, the Past-President of The Institution of Mechanical Engineers and our respective Secretaries, I am setting out on a world tour, primarily to attend a Commonwealth Engineering Conference in Australia, and a EUSEC Conference in New York. This emigration, as it were, of some of us from the professional Institutions to Australia and to America is, I think, a sign of the times. We are realizing the necessity of getting closely together on these common problems—and they are common problems. In fact they are world problems, because my understanding is that wherever in the world there is an advance in electronics and in the field of manufacturing

generally, there is a shortage of well-trained people. These are difficulties that we have to overcome.

'Sir Winston Churchill once said that difficulties mastered are opportunities won, and if this great Institution of ours will have mastered a few of the difficulties during my Presidency, I should like to think that in future years these will appear as opportunities both for this great country of ours and for the rising generation in whose hands the future lies.'

Next Sir Gordon Radley proposed the toast of 'Our Guests' as follows:

'It is a very great privilege to be asked to propose the toast of our guests at this Institution dinner. It is also a task of immense difficulty. To deal with each one of our distinguished guests adequately would take so long that those of you who are, I hope, now comfortably satisfied with Grosvenor House food and wine would be hungry again. Clearly, some method of classification is necessary, and surely it should not be beyond the power of an official of the Post Office to sort our guests out, with due deference of course, as if they were letters and put them into their proper pigeon-holes. But this requires some co-operation of the public, and I doubt whether all our guests, despite their distinction and despite our efforts, have even mastered the rudiments of clear and correct addressing. Is it not a fact that a Master of Trinity, having misdirected a letter, received a reply addressed to "Trinity College opposite Matthews the grocer's"? I wish I had the Postmaster General here this evening. He is much better at dropping things through the right letter-box than I am!

The Rector of Imperial College, South Kensington, amuses two men from Trinity College, Cambridge

'In my perplexity I at last decided upon the broadest possible form of classification. It must be between those of our guests whose company we have enjoyed and who, I trust, have enjoyed ours, untroubled by the necessity of making last-minute notes for a speech, and those—with whom I now have more sympathy than ever before—who have to pay for their dinner by speaking. Let us deal first of all with the first category—the untroubled.

'It is a great honour that we have with us Their Excellencies the Ambassadors from three great European countries and the representative of another. We welcome, with them, the representatives of some of those countries which, of their own free will, are finding their place in that brotherhood we know as the British Commonwealth. We should have had as our guest Her Excellency the High Commissioner for India, Mrs. Pandit. We are immensely sorry that she has not been able to come, the more so because her absence is due to the death of a Minister in the Indian Government.

I believe if Mrs. Pandit had been here she would have spoken about technical development in India. India, Ghana, represented by the High Commissioner here on my left, and other members of the Commonwealth are building up their industries. They are developing transport and communications. There is no need for them to turn to the United Kingdom for technical guidance or engineering equipment. The whole world is there to serve them. But we have a fund of experience and some achievement in that branch of engineering founded on the discoveries of Michael Faraday, in radio and telecommunication and, above all, in the development of nuclear energy as a source of industrial power. Like Prometheus we stand, not with the gift of fire but with the illimitable power released from the parted atom. And we are glad that Sir John Cockcroft, who was the first to split that atom, is here among our guests to-night.

'We have a large number of distinguished guests representing nearly every aspect of our national life. We are pleased to welcome Lord Mills, one of Her Majesty's Cabinet who steer the course of the nation. I also welcome a number of my fellow permanent Civil Servants who, with varying success, try to steer the course of Ministers. We welcome representatives of the Fighting Services. There are not so many as usual to-night; perhaps the defence cuts have already taken their toll. There are also the representatives of our great nationalized industries and the trade associations.

'We welcome the Presidents and Officers of our sister engineering Institutions. Might I on behalf of all present wish them, and our own President and Secretary, the very best of luck as they start out on their world tour to-morrow. Members of The Institution may rest assured that they have persuaded their respective Councils that their journey is really necessary!

'We also welcome many others who have made their contributions in fields far removed from engineering. We, in this Institution, attach great importance to the catholic nature of our guest list. It is our recognition that man has many problems that cannot be solved on the slide-rule. Some of you are trying to tackle the economic problems which confront our nation at this time—problems so clearly described to us last year by Sir Oliver Franks. We believe that we have the measure of them, but it will only be by constant striving and the acceptance of a discipline, which may be inconvenient at times, that they will be resolved. There was an old Methodist parson who was praying for rain at a time of

drought. He said "Lord send a mighty, rushing wind and abundance of rain". As he prayed a gentle breeze came in through the open doors of the chapel and a sheet of his notes fluttered down from the pulpit, whereupon he said, "O Lord, be reasonable in what you are doing".

'Now I come to my second category—the unfortunates—and I start with Lord Adrian, to whom the President has already referred. I think that the Master of Trinity College and Vice-Chancellor of Cambridge University is perhaps more firmly fixed in our minds as the President of the Royal Society from 1950 to 1955. We, as an Institution, are a comparatively juvenile relative of a society which received its Charter in 1662 for "improving natural knowledge". But we, too, have our Charter and

Sir George Edwards causes some chuckles by his views on electrical engineers

our responsibility for the advancement of electrical science and electrical engineering. It is of the interdependence of science and engineering that I would say a word in my welcome to Lord Adrian.

'Zeta may be the result of very profound calculations in the field of nuclear physics, but it was only engineers who could have built the equipment, as it was only engineers who could have launched the first satellite into outer space—and [Sir Gordon turned towards Mr. Malik] Your Excellency, very good engineers too.

'I am quite sure that the material future of this world depends on the engineer taking over ideas from the scientist and developing them, we hope, for the good of mankind. The possibilities are unlimited. You remember that statue in front of the Archives Building in Washington—of a woman sitting with an open book on her knees. Underneath are the words "All that is past is prologue". An explanation of those words given by a passer-by was "Well, mister, that means that you ain't just seen nothin' yet".

'That brings me quite happily to the other name in my second category, Sir George Edwards, who has been turning over many of the pages in that book. We are immensely grateful to him this evening for standing in at short notice to reply to this toast, particularly as it was only yesterday that he gave his Presidential Address to the Royal Aeronautical Society. But with great generosity he agreed to speak to us. He comes to us not only as the President of that Society, but as leader of a team who produced that masterpiece of British engineering, the Viscount aircraft. I do not know whether I should welcome him as Viscount Edwards. Anyhow, welcome him we do most sincerely, and all our guests.

'Members of The Institution, I ask you to rise and to drink with me the health of all our guests, coupled with the name of Sir George Edwards.'

The last speech came from Sir George Edwards, who in reply to Sir Gordon Radley said:

'As Sir Gordon Radley has already warned you, there has not been a great deal of time to prepare a dissertation, and I think my nerve would have failed me had there been. When I accepted your President's invitation to reply to this toast, I may say that I had no indication at all of the lustre of the guests for whom I was rash enough to say I would reply. There are a great many among the guests here to-night who could do the job a great deal better than I. The fact remains, however, that here I am and you, Sir, have asked for it!

'The last time I addressed The Institution was during the time when Sir George Nelson was President, and I was invited to open the Convention on Electrical Equipment of Aircraft. I was presented for the first time in my professional career with all the aircraft electrical equipment designers drawn together in one room, imprisoned there with no escape; and you can take it from me that they had the fullest treatment that I could muster for the suffering which they have handed out to me and to colleagues over a great many years. Although I went to the trouble to stick to the facts, I did not waste any time by telling them any favourable facts. I did, as I believe is generally considered to be the right thing to do when making—I almost said a "political" and then nearly changed it to "diplomatic" speech, but realizing where I am I will not say either—a speech of this sort. I stuck to the facts which I wanted to get across and which I regarded as being tolerably unpleasant. Whether it is the warm nature of the hospitality we have received as your guests to-night, the graceful manner in which this toast was proposed by Sir Gordon or the warm way in which the company received it, I find it incumbent upon me to report to those who may have been present on that particular occasion that the current position shows a significant improvement. Although you are a long way from being all right, you are certainly doing better than you were! That is not to be taken as a signal for sitting back and not worrying any more and letting the traces of solder creep across the terminals. It is to be taken as some encouragement to go and do better still.

'I can report that there is progress in the efforts of

your Institution to get more trained engineers and scientists. If the current members go on doing as well as they are doing, they will, with luck, get enough orders to give the new scientists jobs when they are trained as well!

'I am not sure whether that is really very funny, because I wonder how much the shortage of trained engineers, scientists and professional men may be traced to the relative lack of inducement which a highly trained man has had over the years, compared with what he has seen people getting who have had virtually no training at all.

'Lord Adrian referred to the things he saw in Moscow. I had the opportunity, by courtesy of the Government which Mr. Malik represents, to go there not so long ago on an air mission. In this general context of training scientists and engineers, I think that the thing which stands out like a symbol in Moscow when you come into the airport is the enormous university. There is the visible sign of the things that we have subsequently seen. We had an opportunity to talk to the professional men and those whose names in the aircraft industry in Russia are held in great esteem, and you can take it from me that there is no doubt in the minds of the team that went there that the products of that university will stand comparison with the products of any other.

'We have another thing in common—and we are apt to make Americans cross when we tell them it—namely that in this era of turbine engines it is an undeniable fact that all the airline operating experience in gas-turbine engines has so far been British and Russian—predominantly British.

'I have been to a Royal Aeronautical Society Council meeting this afternoon and when the people there knew I was coming here to make a heavy statement, the Chairman of the new "Guided Flight Section" said, "I think it would be a good thing if you mentioned the Guided Flight Section of the Royal Aeronautical Society, because its aim is to get people in the guided weapons business to join us now that we are not going to have any more manned aeroplanes. There might be some people in the Electricals, therefore, who think that we are trying to poach some of their members for the Aeronautical Society. If you can say tactfully that really friendly relations still exist, we think it would not be wasting all your time." I said I would do this as tactfully as I could, but I must say, when I listened to your President saying that there were no less than 42000 of you, I decided that even if a few did trickle out, you would not know. When I looked round this room I decided there was no trouble at all, and that any of you could pay two subscriptions without noticing, quite apart from the fact that you would obviously have no trouble at all in saying that both those subscriptions were essential for your employment.

'I am sure it would be right for me to be very honest and very sincere when I wish the best of luck and prosperity to The Institution of Electrical Engineers and to all electrical engineers. They have now a grip on almost every industry there is in this country. There is not a thing that any engineering industry can do now in which electrics or electronics—which is only electrics with a gap somewhere in the wire—do not make a contribution. The only thing I hope is that you really fully understand the responsibility which is yours at the same time.

'For years now American electrical equipment, particularly in aeroplanes, has been held up generally to be better than British. I believe that is not true any more. I believe you are doing all right, and there is one thing I would say if I may be allowed to offer a word of advice. Where we can always maintain a competitive position with the Americans is in having flexibility in what we are doing. In that way, with their general lack of flexibility, their disinclination to make changes in design half way down the production line, they can be beaten with the weapon which they do not use. In order to be competitive we have had to use this weapon from the start. It has been necessary to make changes on short runs, and quickly to inject changes and modifications which have been a pain in the neck to the fellows on the production line. But we have succeeded in doing something which the Americans will not do. Our experience of their accessory manufacture is that they still do not want to do it, and if we really want to show that British aeroplanes and designers are better than anybody else's, the way to do it is to get more flexibility in the set-up so that you can start changing things for the better a bit sooner. That is not intended to be churlish. It is intended in the best possible spirit, because those of us in the aircraft industry who, after considerable exhortation from the Government, have put great sums of private money into the development of aeroplanes, know that the safety of that money is absolutely dependent on the reliability of the equipment which your members produce.

'May I say again to you and your Institution on behalf of the guests, "Thank you for your welcome and your hospitality, and for this warm and friendly evening." Thank you, Sir Gordon, for such a graceful toast, and thank you, members, for having so warmly received it.'

TRAINING PRODUCT DESIGNERS

An article with the above title appeared in the April issue of *Design*, which is published by the Council of Industrial Design. The importance of product design (or appearance design as it is sometimes called) is well known to those in the electrical manufacturing industry, and the article constitutes a noteworthy discussion of the kind of training which prospective designers should receive. It describes the courses at present available, and emphasizes the need to attract intelligent and enthusiastic students and to ensure that their training will be realistic as well as artistic.

The April issue of *Design* may be obtained from the Council of Industrial Design, The Design Centre, 28 Haymarket, London, S.W.1, price 3s. 9d. post free.

SHORT REVIEWS OF PAPERS

Natural Convection in Transformers

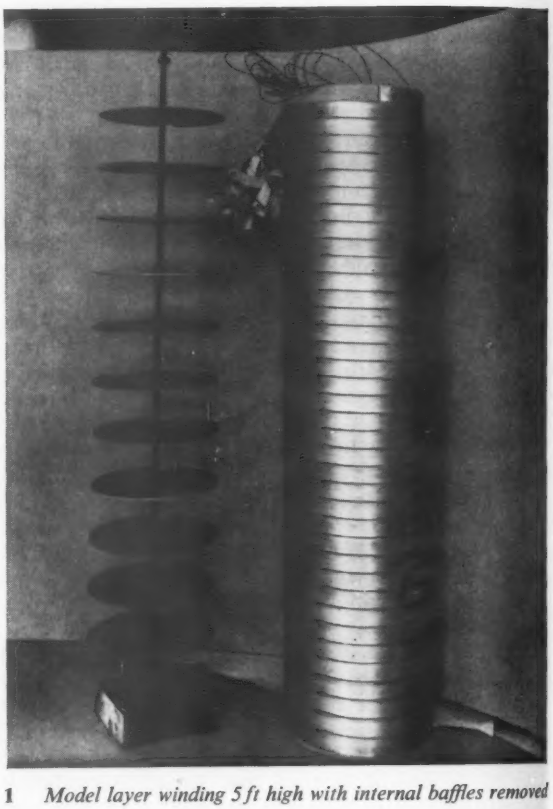
A short review of a Supply Section paper (No. 2505) entitled 'An Experimental Approach to the Cooling of Transformer Coils by Natural Convection', by E. D. Taylor, M.Sc., Associate Member, B. Berger, B.Sc.(Eng.), Associate Member, and B. E. Western, B.Sc., Associate Member. The paper was published in April 1958 in Part A of the Proceedings. The authors are with C. A. Parsons and Co.

ALTHOUGH THE SUBJECT OF TRANSFORMER COOLING IS NOT new, a comprehensive experimental treatment of natural convection in layer and disc coil windings, together with comments on other available information, has not yet been published. In their paper the authors attempt to fill this gap.

For the experimental work, the authors used specially constructed model coils in order to obtain a wide variation of duct size, coil height and other parameters. The fact that the results are not only self-consistent but in reasonable—sometimes close—agreement with the results of tests on a number of commercially produced transformers suggests that the experimental data obtained from the models provide a satisfactory conception of the heat-exchange mechanism in a transformer.

Clean transformer oil was used as the cooling fluid in all experiments except those on a 2 ft-model layer winding, where the coil was immersed in a coolant of the chlorinated-diphenyl type. All the models were mounted 9 in. below the liquid surface in the tank. Tank sizes varied according to the model tested, but were sufficiently large to provide an ample volume of oil. Fig. 1 shows a typical model of a 5 ft layer winding. The coil consisted of a spiral of bare copper strip wound on a thick Bakelite tube and heated by direct current. The baffles within this tube retarded and made precise any internal heat transfer. To form a vertical duct the coil was concentrically surrounded by a Bakelite tube of appropriate internal diameter. Copper-constantan thermocouples measured coil and oil temperatures at many points.

The cooling of transformer coils is in principle a simple mechanism. It consists of two stages: first, the flowing liquid absorbs heat from the coil surface and, secondly, the liquid transfers it to the atmosphere as it sinks down along the tank wall. It is the second stage of the mechanism that determines the top and bottom oil temperatures in the transformer tank immediately above and below the winding. The influence of the external tank conditions can be demonstrated by an experiment in

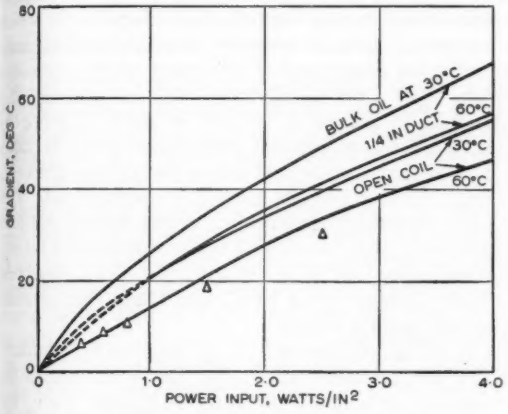


1 *Model layer winding 5 ft high with internal baffles removed*

which the temperature distributions are compared when the same layer coil is dissipating the same energy in different positions in the tank. Although the copper temperatures happen to be similar, the top and bottom oil temperatures are quite different. The distribution at the tank wall adjusts itself to enable the oil to dissipate the energy loss of the coil to the atmosphere surrounding the tank. The shape of the oil-temperature distribution in the duct is then determined by the duct size. It turns out that although these differences in shape are distinctly observable they are small, and a linear distribution of duct oil temperature may be assumed with little error.

The shape and size of the cooling ducts are naturally bound up with the construction of the coil, and layer-type and disc-type windings have to be treated separately. The copper temperatures in a layer-type winding are determined by a simple temperature gradient, coil to oil. For transformer oil the gradient increases with power

input and decreases with oil temperature and duct size, but is independent of coil height except very close to the entrance (Fig. 2). The gradient curves for the chlorinated diphenyl coolant have approximately the same shape and magnitude, but are independent of duct size as well as coil height. The copper temperatures in a disc winding are not related to the oil temperatures in such a simple way. The horizontal ducts between adjacent discs produce a heat-exchange mechanism which is profoundly affected by changes in duct length and height. If the duct height is very small the heat transfer is almost entirely by conduction, but as the height is increased convection gradually becomes predominant. The overall results are best expressed on a heat-transfer curve drawn to scales



2 *Mean gradients for layer windings*
△ Gradients for oil at 60° C obtained by other workers.

which involve both duct and fluid parameters. With this conception, the mean temperatures of the disc coils of a complete winding form a locus consisting of a section of this curve. The extremities of the section are determined by the top and bottom oil temperatures, which are in turn determined by the external tank conditions.

It is a sensible practice in heat transfer investigations to correlate the results with those of other workers. This was not possible for the disc-coil winding since, as far as the authors are aware, no related information has been published. With regard to the layer winding, the correlation formula is of limited use to the transformer engineer. Although interesting theoretically, particularly from a pure heat-transfer point of view, the formula is inadequate for a detailed study of local temperature rises and gradients.

The maximum temperature in a transformer is of particular concern to the engineer since it is held to determine the life of the insulation. This temperature cannot be measured directly and a number of empirical relations have been proposed to enable the maximum temperature to be deduced from temperatures which can be measured, such as the top oil temperature and the mean winding temperature. Different countries favour different types of empirical formulae, and the paper comments on their validity. It also proposes a method of assessing the 'hot-spot' temperature of a transformer in service which does not require the measurement of mean copper and mean oil temperature. 621.314.2—711

Computers in Nuclear-Reactor Design

A short review of a Measurement and Control Section paper (No. 2507) entitled 'The Application of Digital Computers to Nuclear-Reactor Design', by J. Howlett, B.Sc., Ph.D., Associate Member. The paper was published individually in January 1958, and it will be republished in Part B of the Proceedings. The author is at the Atomic Energy Research Establishment.

THE DESIGN OF A NUCLEAR REACTOR TO PRODUCE ELECTRICAL power at economic cost, or to any other well-defined specification, involves an enormous amount of computation, far more than can be done by hand in any reasonable time. The reasons for this lie in the complexity of the nuclear and other physical processes occurring in the reactor, the elaborate nature of the data entering into the calculations, and the number of parameters in the design which can be varied to affect the performance, the stringent conditions imposed by safety and economic needs, and the high precision (relative to their difficulty) to which many of the calculations have to be carried. Most of the demands are associated with the neutron transport phenomena, but there are also problems arising from heat transfer and from the interpretation of the experimental work carried on in connection with the design study. The reactor engineers and physicists are interested fundamentally in the properties of the neutron population existing in the reactor—the variation of its density in space and in time and the distribution of energy among the neutrons. All other quantities of interest depend on these, such as the critical size, the time variation of power level following control-rod movements, shielding requirements, burn-up of fissile material, and production and decay of fission-product poisons with consequential effects on the reactivity.

There are broadly two ways of formulating these neutron-transport problems. One is to compute theoretical life histories of random samples of neutrons and to use statistical techniques to infer with calculable precision the properties of the population as a whole; this is a particular use of what is called the Monte Carlo method. The other is to regard the neutron population as continuous and, as in hydrodynamics, to set up a general equation of conservation. Particular problems are then represented by particular forms of this equation.

The Monte Carlo method is completely general; whatever is known about the physics of the system—for example the variation of cross-sections with energy for the materials of the reactor—can in principle be used in the calculation without approximation. Any geometrical

arrangement can be taken into account—in particular, the presence of internal voids, which, though very difficult to treat analytically, present no problem in this approach. But the amount of computation in a complicated problem is likely to be very great indeed, especially if high precision is wanted, for the precision of a result will usually increase only as the square root of the number of neutrons in the sample. A rough-and-ready guide is that a sample of about 10000 neutrons will give results to within about 1%. The method is essentially one for use with fast automatic machinery and could not be properly used until this became available. An example is the calculation of an important quantity called the resonance escape probability for a thermal reactor, which is the probability that a neutron will not be lost by capture in a uranium nucleus during the process of slowing down from fission to thermal energy. This depends on the nuclear properties of the fuel and moderator and on the geometry of the reactor. Much theoretical work has been done on this problem during the last few years using Monto Carlo techniques. A set of calculations made for a lattice of canned uranium rods in a graphite moderator, to explore the effects of different parts of the energy range, used samples of 4000 neutrons, following each neutron through about fifteen collisions, and gave values for the escape probability correct to about 2%; each calculation took 25 min on a large fast machine.

The analytical method, applied in the most general way, leads to an integro-differential equation for the neutron density as a function of time, space (3 dimensions) and neutron velocity (3 components). This is quite intractable, either by mathematical methods or numerically with even the fastest of present-day machines. Approximations can be made to suit special classes of problems, leading to situations of which the following are typical.

(1) The large-scale variation of neutron density from point to point in a thermal reactor, ignoring detailed changes close to a fuel element or control rod, is given by a set of simultaneous partial differential equations.

(2) In a reactor in which the fuel elements are arranged regularly in a lattice, the detailed variation across a lattice cell can be found by solving a set of simultaneous one-dimensional integro-differential equations.

(3) For problems on the kinetics of a reactor, such as the rate of rise to power or the effects of accumulation of fission products, it is often adequate to ignore all geometrical effects so that one has to solve a set of ordinary differential equations for the time variations of the quantities concerned.

A typical problem of the first group is that of finding the critical conditions for a cylindrical reactor with side and end reflectors. If one makes the two-group approximation, that is, one assumes that all the neutrons have one or other of two energies, the equations are:

$$D_f\left(\nabla^2 - \frac{1}{L^2}\right)\phi_f + \frac{k}{p}\cdot\frac{D_s\phi_s}{L^2} = 0$$

$$D_s\left(\nabla^2 - \frac{1}{L^2}\right)\phi_s + p\cdot\frac{D_f\phi_f}{L^2} = 0$$

where ∇^2 is the differential operator $\frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{\partial^2}{\partial z^2}$ and, in the standard notation,

ϕ_f, ϕ_s = the fast and slow fluxes (related to neutron densities).
D_f, D_s = the corresponding diffusion coefficients.
L_s, L = the slowing down and diffusion lengths.
k = the multiplication factor for a medium of infinite extent.
p = the resonance escape probability.

These last six quantities depend upon the properties of the materials of the reactor and can vary from one region to another. Both ϕ_f and ϕ_s vanish on the outer surface of the reactor, and what is wanted is the value of k for which the equations have a solution not everywhere zero, this being the mathematical statement of the criticality problem. The only satisfactory way of solving this problem is to reduce it to one in linear algebra by replacing all the differential coefficients by finite differences. One then has the problem of finding an eigenvalue of a matrix whose order is likely to be about 1000. This is a considerable computation involving several millions of operations; with the newest types of machines having a multiplication time of about a quarter of a millisecond it is likely to take about 20–30 min. Hand computation would take several months.

Problems in the second group are treated similarly and are on a similar scale. For the third group the calculations are usually on a much smaller scale, but still formidable from the point of view of hand computation. A study of the build-up of transuranic elements and of fission-product poisons for a uranium-fuelled reactor required the solution of a set of thirteen ordinary differential equations; step-by-step numerical integration on a medium-speed machine took about two seconds per step, which would be reduced by a factor of about ten with the latest machines.

These and many other calculations have to be carried on as regular routines in any organization undertaking reactor studies; such a body will therefore need to have either a machine of its own or access to one and to have programmes available for all standard calculations. Almost every calculation has to be repeated many times with different data as part of the search for optimum values of the parameters of the design. This adds greatly to the efficiency of machine calculation, for, whilst the writing of a general programme to solve (for example) the multi-group diffusion equations is a considerable task for an expert programmer, the programme once written can be used many times over and will give a good return for the effort invested.

Finally, the seriousness of the computing problem associated with data handling and the interpretation of experiments must be stressed, for it is very easy to underestimate this. In the latter, the essential problem is usually to find optimum values for some parameters by fitting (probably by some least-squares method) an

expression (usually of complicated form) to a set of experimental observations. Typical examples are:

(1) The analysis of a composite decay curve into a sum of exponential decays of individual elements, that is, finding coefficients a_r, λ_r, such that

$$N(t) = \sum_{r=1}^{n} a_r \varepsilon^{-\lambda_r t}$$

gives the best fit to observed values of $N(t)$.

(2) The analysis of neutron-flux measurements in a standard type of experiment, in which quantities a, b, h, b_{11} have to be found by fitting

$$\phi(x, y, z) = \sum_{m,n} A_{mn} \cos\frac{m\pi x}{a} \cos\frac{n\pi y}{b} \sinh\frac{h-z}{b_{mn}} \Big/ \sinh\frac{h}{b_{mn}}$$

where

$$\frac{1}{b_{mn}^2} = \frac{1}{b_{11}^2} + (m^2-1)\frac{\pi^2}{a^2} + (n^2-1)\frac{\pi^2}{b^2}$$

to observed values for the flux ϕ at points (x, y, z).

All this implies routine computation on a large scale, a particular feature here being the need for quick results. Data processing is a wide and rapidly expanding field really outside the scope of this paper. One of the main objects of building research reactors and high-energy accelerators, with associated equipment such as neutron spectrometers, is to make accurate determinations of the very extensive nuclear data needed in reactor calculations. These undertakings are so expensive both in capital and running costs that the greatest possible amount of information must be extracted from the measurements made with them; this can be done only by complete mechanization, recording the raw data on magnetic tape, punched paper tape or punched cards and feeding this direct into computing machinery programmed to give the values of the physical properties which the experiments are designed to measure. The problem of recording is as serious as that of computing, and although individual computations are likely to be quite simple the volume of work to be handled is likely to be so great as to make organization one of the most important considerations.

681.142 : 621.311.25 : 539.172.4B

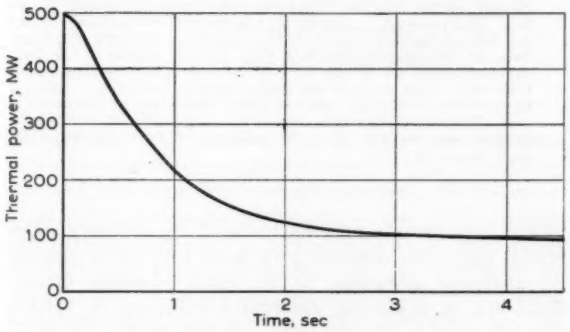
Temperature Transients in Nuclear Reactors

A short review of a Measurement and Control Section paper (No. 2422) entitled 'Temperature Transients in Gas-Cooled Thermal Nuclear Reactors', by J. H. Bowen, B.Sc., Associate Member, and E. F. O. Masters, B.Sc., Associate Member. The paper was published individually in October 1957, and it will be republished in Part A of the Proceedings. Mr. Bowen is with the Industrial Group of the United Kingdom Atomic Energy Authority; Mr. Masters is with Messrs. Preece, Cardew and Rider, and was attached to the U.K.A.E.A. when the paper was prepared.

THE FIRST SERIES OF COMMERCIAL NUCLEAR POWER stations now under construction in this country resemble the Calder Hall station in having reactors fuelled with natural uranium, using graphite as the moderator and compressed CO_2 as the coolant. The coolant gas circulates upwards through vertical channels in the reactor, flows over the hot uranium fuel rods and thence downwards over tube banks in the heat exchangers, transferring the heat to the working substance (water/steam), which is utilized in conventional turbine generators.

In this process, the fuel-element sheaths play an important role. Each bar of natural uranium is clad in a magnesium-alloy jacket, which forms a hermetic container. This is pressed into intimate contact with the bar, and is formed into an extended surface which allows the heat transfer from the uranium to the gas to be effected with minimum temperature drop and maximum thermodynamic efficiency. All reactor and cycle temperatures are limited by the temperature at which the fuel elements are operated, and this is determined by the safe temperature of operation of the magnesium alloy. The cost of a charge of fuel for a Calder Hall type of reactor is about £3 million, of which a significant part is the cost of fuel-element fabrication. In selecting the operating temperatures, careful judgment is required to balance operating efficiency against risk of damage to the fuel charge. It is important to remember that during reactor operation the uranium becomes radioactive, and if a sufficient number of the fuel element sheaths were damaged, the radioactivity could spread throughout the gas circuit, rendering maintenance difficult and expensive. Even so, it may be noted that, since the gas circuit is sealed to contain the high gas pressure, the radioactivity cannot escape from the container at a significant rate.

In selecting the operating temperature for the fuel elements, the possibility must be considered of transient overheating owing either to excessive power generation in the reactor or to some disturbance to the cooling mechanism. Either fault may be corrected by reducing the reactor power, which may be achieved rapidly by the insertion of the control rods. A typical reactor shutdown curve is shown in Fig. 1. In designing a suitable protective scheme, the faults are considered which are

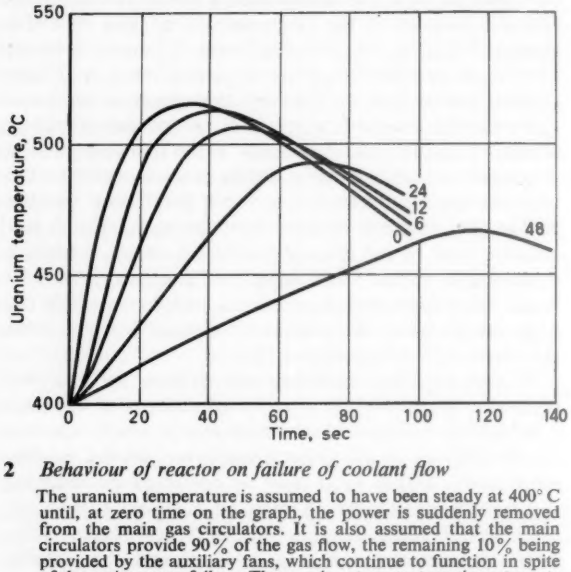


1 *Behaviour of graphite-moderated reactor on forced shutdown*

The graph shows the decrease of thermal power with time, assuming that control rods are inserted at zero time to reduce the multiplication factor from 1·00 to 0·95 in 5 sec.

judged feasible, having regard to the characteristics of the equipment and machinery installed. A number of fault conditions may be selected for which calculations may be made of the mode of development of the fault, assuming that, in the limiting case, no protection or correction is applied. From a knowledge of the rates of development and the amplitudes of various quantities (e.g. fuel-element temperature) during the fault, suitable protection devices may be specified.

In their paper, the authors deal with the calculation of the temperature and power swings which occur when the cooling process is unbalanced. The equations of the process are stated, but are not solved because some complicated partial differential equations are involved. However, a complete solution for a particular example is not beyond the scope of a high-speed digital computer. The authors examine the conditions under which the



2 *Behaviour of reactor on failure of coolant flow*

The uranium temperature is assumed to have been steady at 400° C until, at zero time on the graph, the power is suddenly removed from the main gas circulators. It is also assumed that the main circulators provide 90% of the gas flow, the remaining 10% being provided by the auxiliary fans, which continue to function in spite of the main power failure. The uranium temperature rises at a rate determined by the rate of decrease of gas flow, which depends on the inertia of the main circulators. The graph shows temperature plotted against time for various assumed rates of decrease of gas flow. The parameter actually used is the time in seconds for the gas flow to decrease by 63% of the total drop. The zero parameter indicates an instantaneous 90% drop (i.e. zero inertia of the main gas circulators) and is thus the limiting case. After reaching a peak the temperature starts to fall again because, owing to a negative temperature coefficient, reactor power decreases as temperature rises. The temperature thus rises or falls depending on whether the instantaneous ratio of power to cooling potential is greater or less than the initial ratio.

partial differentials may be replaced by ordinary differential equations depending on time only. This enables an analogue computer to be used, allowing greater flexibility in exploring different conditions. A further simplification is to replace the reactor kinetic equations by a transfer function, which enables approximate solutions to be obtained readily by graphical or simple computing methods. The results obtained in this way were checked over a wide variety of conditions against the solutions yielded by an analogue computer, with satisfactory results.

Having simplified the problem to this degree, the authors discuss the factors which affect transient performance under fault conditions. An example is illustrated in Fig. 2, which shows the temperature transients predicted for a particular reactor, resulting from a failure of the driving power of the gas circulators. Owing to the inertia of the rotating impellers, the flow of gas does not cease abruptly, and the Figure illustrates the changed form of temperature transient due to different values of circulator inertia. From studies of this type, a satisfactory value of inertia may be chosen for a given system.

Similar methods are applied in the paper to show how the behaviour of a reactor, when being started up by the withdrawal of the control rods, depends on the speed of motion of the rods, the thermal characteristics and the spontaneous (or starting) power of the reactor. Thus, the effect of a neutron source in expediting the start-up process can be explained. 539.172.4

Neutron Counters

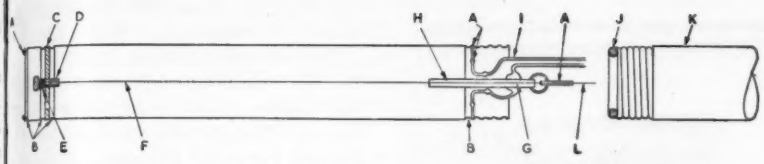
A short review of two Measurement and Control Section papers (Nos. 2542 and 2546) entitled 'Boron Trifluoride Proportional Counters' and 'The Design, Performance and Use of Fission Counters', by W. Abson, B.Sc., Associate Member, P. G. Salmon and S. Pyrah. The papers were published in January 1958, and they will be republished in Part B of the Proceedings. The authors are at the Atomic Energy Research Establishment, Harwell.

TWO TYPES OF GAS-IONIZATION COUNTER WITH A WIDE range of application as neutron detectors in nuclear-physics experiments and nuclear instrumentation systems are boron-trifluoride (BF_3) proportional counters and fission counters. In both types the absorption of a neutron (in boron 10 or in fissile material) is followed by the emission of high-energy ionizing particles; the ionization produced by these particles in the gas of the counter is collected and the resulting voltage pulse amplified and registered. The maximum energy released in the (n, α) reaction with boron 10 is 2·4 MeV, and it is usually necessary to make use of secondary ionizing processes (gas multiplication) to obtain an easily detectable voltage pulse. In the neutron-fission process the energy of the fission fragments is much greater (total energy release $\sim$ 160 MeV) and the detector can take the form of a simple two-plate electron-collection ion chamber.

The chief features of the neutron reactions with boron 10 and uranium 235, which are of interest in the design of thermal-neutron detectors, are given below:

(n, α) reaction in boron 10 (cross-section for thermal neutrons $\simeq 4000 \times 10^{-24}$ cm^2).

$$_0^1n + {}^{10}_5B \rightarrow {}^7_3Li + {}^4_2He$$



1 *General construction of 1 in. cathode-diameter BF_3 proportional counter*

Anode diameter = 0·002 in. Counter body is constructed of high-conductivity oxygen-free copper.

A Hard-soldered at these four points using silver/copper eutectic solder of melting point 778°C.
C Swages rolled into body for location of end-caps and for locking quartz disc.
C Quartz disc.
D Tube for end termination, spring-loaded.
E Inconel coil spring.
F Tungsten or Inconel wire anode.
G Spot weld to anode wire.
H Guard-ring electrode.
I Glass/metal seal.
J O-ring seal.
K Screwed end-cap of appropriate length, fitted with optional end termination, provides air-tight joint when screwed into counter body.
L Nickel wire.

Total particle energy	$\simeq 2{\cdot}4$ MeV
Combined range in BF_3 gas at s.t.p.	$\simeq 0{\cdot}5$ cm
Maximum ionization charge available	$\simeq 7 \times 10^4$ ion pairs or $1{\cdot}2 \times 10^{-14}$ coulombs

(n, fission) reaction in uranium 235 (cross-section* for thermal neutrons $\simeq 590 \times 10^{-24}$ cm^2).

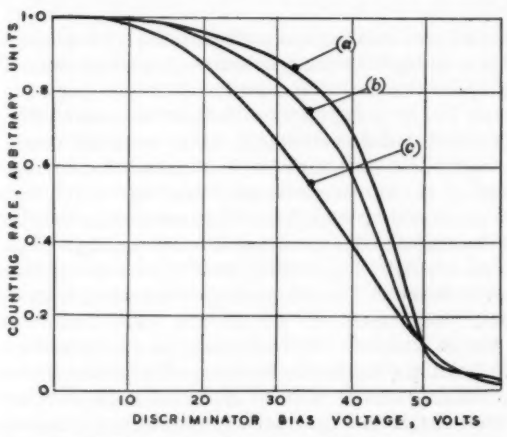
$$^1_0n + {}^{235}U \rightarrow X + Y \text{ (fission fragments)}$$

Total particle energy	$\simeq 160$ MeV
Combined range in argon at s.t.p.	$\simeq 3{\cdot}0$ cm
Maximum ionization charge available	$\simeq 5{\cdot}5 \times 10^6$ ion pairs or 9×10^{-13} coulombs

Fig. 1 shows an example of a boron-trifluoride proportional counter. The cylindrical metal envelope contains BF_3 gas, which acts both as a source of boron 10 and as an ionization-detection medium. A positive potential is applied to the central wire anode so that the electrons produced in the ionizing tracks of the $^7_3$Li and $^4_2$He particles are attracted towards it, and, with a sufficiently high potential on the anode, these electrons may acquire sufficient energy to produce further ionizing collisions. As the anode voltage is increased, a cascade of these secondary collision processes occurs, and the overall gas-multiplication factor M increases exponentially with the applied voltage. Values of M in the range 1–300 may be used with the counter operating in the proportional region, i.e. output pulse proportional to initial or primary ionization.

The voltage pulse induced at the anode is due almost entirely to the movement of the positive ions formed close to the anode in the gas-multiplication process. This pulse rises sharply at first (for a few microseconds) and then more slowly until the positive ions are finally collected at the cathode, about 100 microsec later. A pulse amplifier, whose bandwidth is defined by RC differentiating and integrating circuits, is used to amplify the pulses. With RC values of the order of 1 microsec, only the initial movement of the positive-ion sheath is effective. The pulse amplifier is followed by an amplitude-discriminator circuit, which is so adjusted that neutron pulses are registered and smaller unwanted pulses due to noise or gamma-radiation effects are rejected. The primary ionization in the gas may be less than the maximum available from an (n, α) event because of absorption of particle energy within the walls, and hence there will be a spread in the observed pulse-height distribution. Fig. 2 shows counting-rate/discriminator-bias characteristics for 1 in. diameter counters and several gas pressures. At a typical operating point on the plateau region of the bias curve and with amplifier time-constants of the order of 1 microsec, the effective pulse amplitude at the input to the amplifier is about $M/C \times 10^{-3}$ volts, where C is the total input capacitance in picofarads.

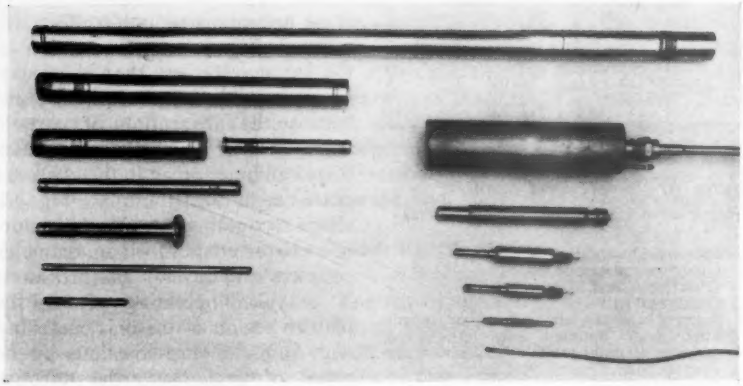
The main problems in obtaining good counting characteristics are associated with purifying the BF_3 gas initially and maintaining it free from electron-capturing impurities for long periods of time after filling the counters. Counters giving consistent results and a good shelf-life have been obtained by the use of a design using oxygen-free copper tubing, with all vacuum joints hard-soldered by means of eddy-current heating in an atmosphere of forming gas and without the use of fluxes. The design is applicable to large-scale production and has been adapted to the manufacture of counters of various sizes. Fig. 3 shows a photograph of some of these counters, and some details of their sensitivities and operating voltages are given in the table overleaf. The larger sizes



2 *Integral bias curves for 1 in. diameter BF_3 counters with 0·002 in. diameter anode wires*

a BF_3 Pressure 70 cm Hg; anode voltage 2 400 volts; $M = 40$.
b BF_3 Pressure 40 cm Hg; anode voltage 1 800 volts; $M = 40$.
c BF_3 Pressure 20 cm Hg; anode voltage 1 200 volts; $M = 40$.
Amplifier setting: Gain = 2×10^4.
Differentiating time-constant = 0·8 sec.
Integrating time-constant = 0·08 sec.
Total input capacitance = 120 pF.

* The capture cross-section σ may be defined as follows: the number of neutron reactions occurring per second, in a sample containing N target atoms irradiated by a flux of n neutrons/cm^2/sec, is $n\sigma N$, provided that the fractional absorption of neutrons in the target is small.



3 *A selection of typical neutron counters*

Left BF_3 proportional counters, of sizes ranging from 43 in. × 2 in. diameter to 2 in. × ½ in. diameter; thermal-neutron sensitivities range from about 200 to 0·3 counts/unit flux.
Right Fission counters, of sizes ranging from 12 in. × 3½ in. diameter to 2 in. × ½ in. diameter. With a uranium 235 coating of 1 mg/cm² the thermal-neutron sensitivities range from about 1·0 to 2 × 10^{-3} counts/unit-flux.

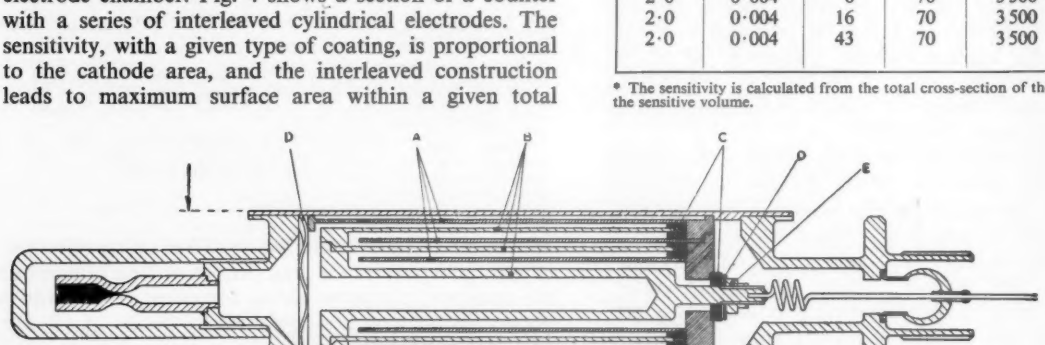
of counter are often used in multiple arrays, for example as large-area high-efficiency detectors in neutron time-of-flight spectrometers. The smaller counters (e.g. ½ in. diameter × 2 in. long) may be used for the measurement of neutron-flux distribution (e.g. in 'zero-energy' reactor core assemblies). Although single gamma pulses may be rejected by the amplitude-discriminator circuit, multiple pulses may occur at high levels of gamma radiation. The effect depends on counter size, and in a 6 in.-long × 1 in.-diameter counter the limiting level of external gamma radiation dose-rate for adequate discrimination is in the region of 100–200 r/h.

In fission counters, the fissile material is deposited as a thin coating (usually in the form of a hard adherent oxide coating) on the surface of the cathode of a two-electrode chamber. Fig. 4 shows a section of a counter with a series of interleaved cylindrical electrodes. The sensitivity, with a given type of coating, is proportional to the cathode area, and the interleaved construction leads to maximum surface area within a given total volume. The maximum range of the fission fragments in the coating is equivalent to a thickness corresponding to a few mg/cm², and if 100% detection efficiency is to be achieved the coating thickness must be restricted to about 0·1 mg/cm² to ensure that one or other of the two fission fragments emerges into the gas space between the electrodes. With coating thicknesses of 1 and 2 mg/cm², the percentage of fission events detected is reduced to about 70% and 60% respectively. The counters are used with a pulse amplifier and amplitude-discriminator unit in the same way as BF_3 proportional counters. Fig. 5 shows counting-rate/discriminator-bias characteristics for a series of coating thicknesses of weights up to 3·2 mg/cm². The counter must be operated at a bias level above that at which alpha emission from the fissile coating is registered. The electrode spacing d and gas pressure p (argon + 2% nitrogen) are usually adjusted to give a value of pd of about 1·0 atm-cm, in order to obtain maximum pulse size. An anode/cathode voltage of about

Typical sizes and sensitivities of BF_3 counters

Cathode diameter	Anode diameter	Sensitive length	Gas pressure	Anode voltage for M = 40	Approximate sensitivity*
in.	in.	in.	cm Hg	volts	counts/sec per unit thermal neutron flux
0·5	0·001	2	40	1 200	0·3
0·5	0·001	11	40	1 200	1·7
1·0	0·002	5	40	1 800	3·0
1·0	0·002	12	70	2 400	13·5
2·0	0·004	6	70	3 500	27·5
2·0	0·004	16	70	3 500	73
2·0	0·004	43	70	3 500	196

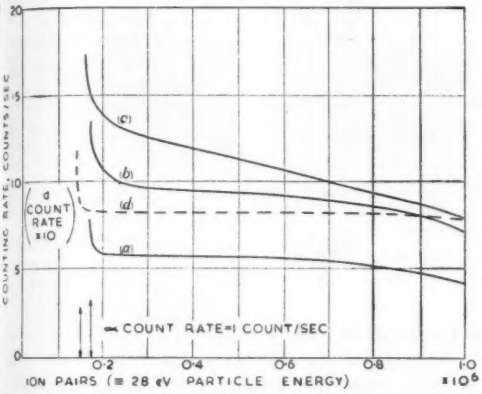
* The sensitivity is calculated from the total cross-section of the boron 10 within the sensitive volume.



4 *Multiple-plate fission counter*

Coatable cathode area = 165 cm². Electrode spacing = 0·1 cm.
A Coated cathode tubes. B Anode. C Quartz insulators. D Nimonic springs. E Fixing nut for anode/cathode assembly.

1000 volts (depending on the details of electrode spacing and gas pressure) is required to prevent appreciable recombination of the primary ionization. For coating thicknesses up to 1 mg/cm² the effective pulse height on the plateau region of the discriminator bias curve is equivalent to a charge of $0{\cdot}4 \times 10^6$ ion pairs or 6×10^{-14} coulombs. The voltage pulse for a total input capacitance of C picofarads is then approximately



5 *Fission-counter sensitivity: dependence on thickness of fissile material coating*

Discriminator-bias curves for
a 1·0 mg/cm² cathode coating.
b 2·1 mg/cm² cathode coating.
c 3·2 mg/cm² cathode coating.
d 0·12 mg/cm² cathode coating.

$6/C \times 10^{-2}$ volts; this is equivalent to the pulse from a BF_3 proportional counter operating at a gas gain of about 60.

With both types of counter it is advisable to limit the total input capacitance so that the input sensitivity required in the pulse amplifier is 200 μV, and preferably higher, in order to be free from amplifier noise and to minimize the effect of spurious pulses from electrical interference. The upper limit of the pulse counting rate is determined by the effective response time of the counter/amplifier system, with differentiating and integrating time-constants of about 0·16 microsec. BF_3 counters 1 in. in diameter may be used for up to 10^5 counts/sec with 10% counting losses, and fission counters for up to about 3×10^5 counts/sec.

Uranium 235 is used as the coating material in fission counters when maximum sensitivity for thermal neutrons is required. For coating thicknesses equivalent to about 1 mg/cm² the thermal-neutron sensitivity is approximately 1 count/sec per gram of uranium 235. The fission counters shown in Fig. 3 have cathode areas of 1 500 cm². Although ^{235}U fission counters have a much lower sensitivity than BF_3 counters of comparable size, the greater energy release following neutron absorption enables them to be used at much higher levels of gamma radiation. For example, the small ¼ in.-diameter counter shown in Fig. 3, which was designed for neutron-flux distribution measurements, may be used in gamma dose-rates of the order of 10^6 r/hr.

The fission counter also has applications for fast-neutron measurement, for which uranium 238 and thorium 232 (which have neutron/fission thresholds in the region of 1 MeV) may be used as coating materials.

539.1.07 : 621.387.4 : 621.387.426.2

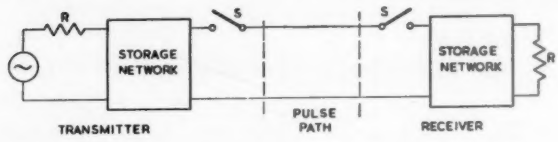
Pulse Amplitude Modulation

A short review of two Radio and Telecommunication Section papers (Nos. 2474 and 2475) entitled 'Efficiency and Reciprocity in Pulse-Amplitude Modulation: Part 1—Principles', by K. W. Cattermole, B.Sc., and 'Efficiency and Reciprocity in Pulse-Amplitude Modulation: Part 2—Testing and Applications', by J. C. Price, B.Sc. The papers were both published individually in December 1957, and they will be republished in Part B of the Proceedings. The authors are with Standard Telecommunication Laboratories Ltd.

THE TRANSMISSION OF PULSES TO REPRESENT A SERIES OF sampled amplitudes of a speech signal is an established technique of radiotelephony. Over the last few years it has also become recognized as a means of using the high operating speed of electronic circuits to best advantage in telephone switching. The problems are not quite the same, however, since in the telephone exchange the signal is not degraded by a long, noisy and band-limited path. The primary requirements are economy and reliability, because of the large quantities of apparatus used, together with the good level stability and crosstalk margins needed throughout the telephone network. Conventional pulse modulators and demodulators have two drawbacks not shared by their counterparts in continuous-wave carrier systems—they introduce a large loss, and work in one direction only. Thus two paths are required for a telephone conversation, either physically distinct or as interlaced pulse trains, and each path must have a high gain.

These drawbacks have been removed by the discovery of a method of conveying signal power through the entire path with low loss. A continuous signal is converted into a modulated pulse train of substantially the same mean power, and the pulse train is similarly reconverted to a continuous signal. Each process requires energy storage in a reactance network which may be charged and discharged at different rates. In a modulator, the store is charged by a substantially smooth flow of power from the signal source, and discharged rapidly to yield a short pulse. In a demodulator, the store is charged by a pulse of energy, and discharged to provide a substantially smooth flow of power. Either circuit consists essentially of a passive reactance network to which the pulse path is periodically connected by an electronic switch to obtain an impulsive charge or discharge. Fig. 1 shows the essential parts of a communication channel. If the switches S are closed for a fraction $1/A$ of the interval between successive closures, a continuous signal of unit power applied to the transmitter

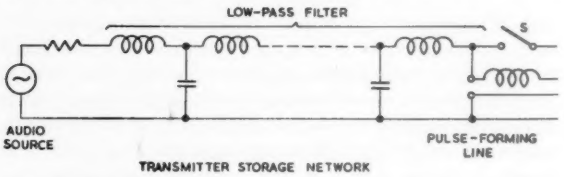
produces an interrupted signal of peak power A in the pulse path and a continuous signal of unit power (save for small losses) in the receiver load R. Practically, A is in the region 50–100 for a 25-channel signal. In the



1 *Storage pulse-amplitude-modulation transmission system*

experimental work the authors used 2 microsec pulses at 100 microsec intervals.

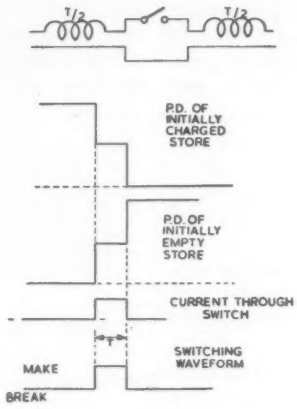
Although rudimentary stores—even a single capacitor—can give a useful improvement over simple sampling, the use of a more elaborate network, such as that in



2 *Storage network*

Fig. 2, is almost always justified, and its design is the principal problem of the system. The delay line or network provides on discharge the short pulse width (2 microsec in the present example) and also constitutes the terminal capacitance of a low-pass filter whose cut-off frequency is not more than half the sampling frequency (in this example, not more than 5 kc/s). The optimum networks are the same for transmitting and receiving. The modulator and demodulator are exactly alike, the one device which can perform either function being called a *modem*. The whole transmission path is symmetrical, and therefore reciprocal.

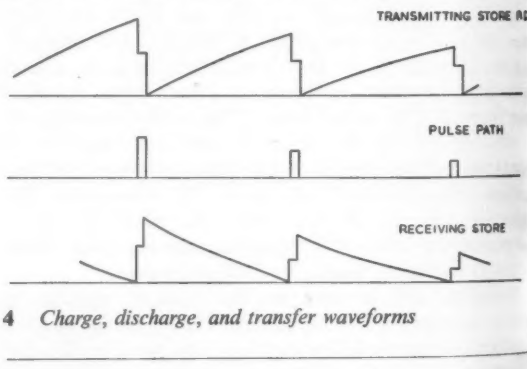
During the relatively short pulse, the change of current in the filter inductors is very small and may be neglected. The action in the pulse path of a symmetrical system (Fig. 1) using the stores of Fig. 2 is therefore essentially that of two delay lines or networks, which, having been charged by some means to different potentials, are connected for a short time by a switch. Fig. 3 shows the waveforms to be expected when initially one store has zero charge and the other is charged to a potential V. When the switch is closed each line 'sees' a matching termination, and the terminal p.d. jumps to $V/2$. The step of potential is propagated along each line, reflected at the far end, and after a period T of twice the transmission delay returns to the near end. If the switch continued to conduct, the charge would oscillate between the two stores, but since it is opened at this instant the charge remains in the initially empty store, whose potential is raised to V by reflection while the other store falls to zero. If each store is charged initially, the pulsed connection causes them to exchange charges.



3 *Interchange of charges in delay lines*

The line sections may be replaced by a single capacitor and inductor, the transfer waveform then being a half sine wave in place of a square pulse. Also, if the shunt capacitance of the pulse path is not negligible, it may be incorporated in the transfer network design.

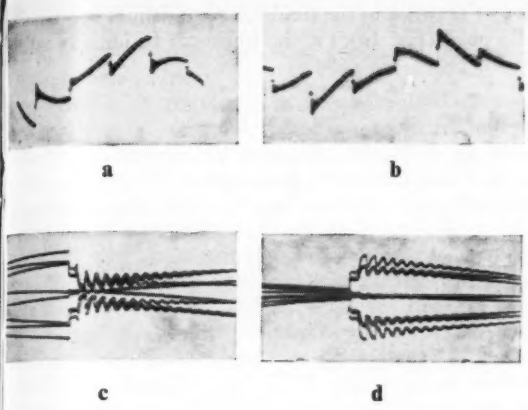
The filters isolate the speech circuits from the rapid transitions occurring in the pulse path, ensuring that the line or capacitor at the pulsed end of a transmitting store charges up smoothly by continuous flow of power from the source, while the receiving store discharges smoothly into the load. The basic waveforms in the pulse path, and at the ends of the stores adjacent to it, are shown in Fig. 4. Typical oscilloscope traces seen with



4 *Charge, discharge, and transfer waveforms*

sine-wave modulation applied are shown in Fig. 5, traces (*a*) and (*b*) extend over a modulation cycle, and traces (*c*) and (*d*) show the details of the sharp transitions.

Computation of the overall transmission of such a system requires knowledge of the response of the modem networks to modulated pulse trains. Formally, this is just the summation of the response to a succession of single impulses, but to make the resulting expression tractable they are simplified by a separation of variables yielding (i) the shape of the waveform between pulse



5 *Oscilloscope traces*

a Voltage on transmitting modem.
b Voltage on receiving modem.
c Discharge into transmitting line.
d Charge from receiving line.

and (ii) the envelope of samples of the waveform drawn from corresponding points in successive periods. The latter is the more important in this work, and a pulse-sequence impedance function $G(j\omega, t_1)$ is defined which gives the envelope of samples taken immediately after the pulses of a sinusoidally modulated train:

$$G(j\omega) = \sum_{n=0}^{\infty} \varepsilon^{-j\omega n t_1} A(nt_1)$$

where ω is the modulating frequency, t_1 the sampling interval, $A(t)$ the impulse response of the network and n a variable of summation. This may be calculated from the steady-state impedance of the network. An inversion process also exists but is not unique. Similar functions have been used in the analysis of servo systems with intermittent data.

The transmission function $T(j\omega)$ relating the voice-frequency output to the variable-frequency input may be calculated in terms of the steady-state transfer impedance $H(j\omega)$ of the network and its pulse-sequence impedance $G(j\omega)$. It is

$$T(j\omega) = \frac{2CR_1}{t_1} \frac{[H(j\omega)/R_1]^2}{2CG(j\omega) - 1}$$

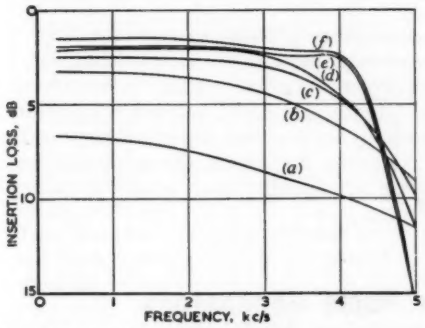
The terminating resistance R_1 is the low-frequency asymptote of $H(j\omega)$. The line capacitance C is also related in a simple way to $G(j\omega)$, whose mean value is $1/C$. Transmission through more complicated channels containing repeaters, cables or intermediate storage can be derived in similar terms. In general, each expression is the product of three terms—a filter transfer function, a constant defining the mean level, and a periodic function depending on the network's impulse response.

The fundamental bounds of the transmission functions turn out to be as generous as could be wished for; it is possible in principle to obtain lossless transmission over a bandwidth of half the sampling frequency. (The band restriction is, of course, common to all sampling systems.) This result can be made plausible without recourse to the mathematical methods used in its derivation, by supposing the filters to have a sharp cut-off at half the sampling rate. The impulse response is then

$$A(t) = \frac{1}{C} \frac{\sin(\pi t/t_1)}{\pi t/t_1}$$

which passes through zero at $t = nt_1$ ($n = 1, 2, 3, \ldots$). Consequently each pulse is transmitted independently. At the time when it occurs, its forerunners have no effect, and there is a simple transfer of the accumulated charge regardless of the form of the modulating signal.

The limiting bandwidth and attenuation are not realizable but may be successively approximated. Measured transmission performance with various networks is shown in Fig. 6. Purely objective measurements



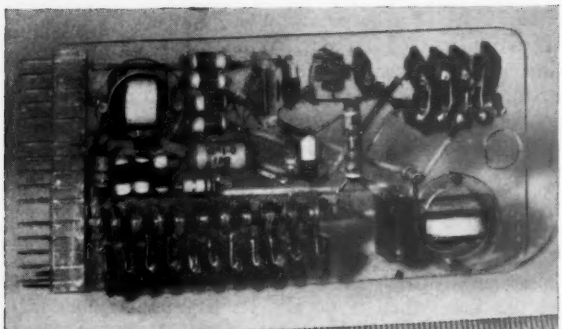
6 *Transmission loss of system*

a One-element filter and delay line.
b Two-element filter and delay line.
c Three-element filter and delay line.
d Four-element filter and delay line.
e Twelve-element filter and delay line.
f Twelve-element filter and tuned circuit.

do not always suffice to assess the practical worth of a system subject to a mixture of imperfections such as band limitation, spurious modulation products, and unfamiliar overload behaviour, and so subjective tests were carried out to decide how good a filter need be used for intelligible and pleasing speech The broad conclusion is that a four-element filter is quite adequate; a critical listener can detect the imperfections, but an habitual telephone user conditioned to accept carbon-microphone speech quality is unlikely to notice insertion or removal of the system in an otherwise direct connection.

The fact that the system is both low-loss and reciprocal implies that it is 'transparent'; impedance changes can be 'seen' through it—that is, current reflected from a mismatch on the output side returns through the modems and is perceptible at the input, and so a voice-frequency equivalent of central-battery signalling is possible.

The electronic switches and generating circuits have been constructed from transistors and diodes, and although it is not essential to use semi-conductors in



7 *Complete panel apparatus for one channel of a telephone terminal*

modems the association is likely to continue. Fig. 7 shows the complete apparatus for one channel of a 24-channel telephone terminal, using point-contact transistors and diodes. Similarly, although there are other applications, by far the most important appears to be telephone switching, for which the economy, low loss, reciprocity, level stability and signalling facility are of notable value. 621.376.53 : 621.395.4

Transistor Pulse Generators for Time-Division Multiplex

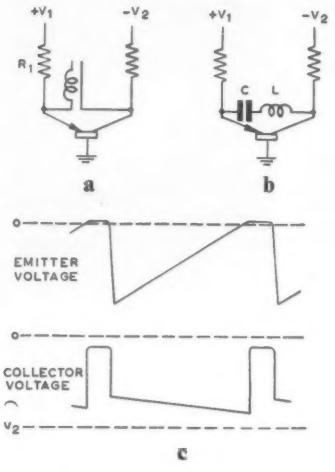
A short review of a Radio and Telecommunication Section paper (No. 2577) with the above title, by K. W. Cattermole, B.Sc. The paper was published individually in March 1958, and it will be republished in Part B of the Proceedings. The author is with Standard Telecommunication Laboratories Ltd.

TRANSMISSION OR SWITCHING OF TELEPHONE CHANNELS by time-division methods requires the provision of many pulse trains at reasonably precise relative time positions. The main functions are:

(1) Generation of simple periodic pulse trains.
(2) Frequency division of pulse trains.
(3) Interlacing of many trains with permanent time positions.
(4) Interlacing of many trains with assignable time positions.

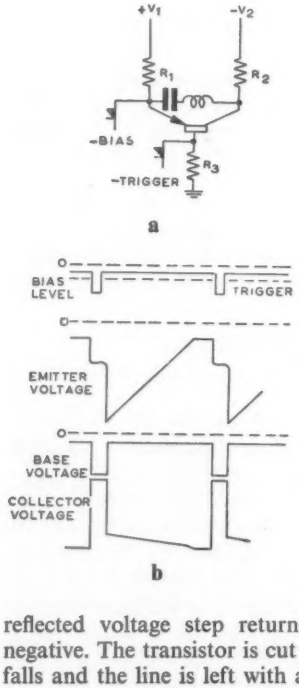
Most of the experimental work was carried out with the timing required for 25-channel telephony with a sampling rate of 10 kc/s.

Since the point-contact transistor has current gain without phase change, a simple feedback element such as an impedance in the base lead or an admittance between emitter and collector is regenerative. A delay line or network in the feedback path defines the duration of a pulse (Fig. 1*a*). Let the transistor be initially cut off,



1 *Pulse generator*
a With delay-line timing.
b With *LC* timing.
c Waveforms.

and the line charged almost to the negative supply potential. Current through R_1 raises the emitter potential; when it becomes positive to base, collector current is turned on, which tends to discharge the line and drive the emitter further positive. This regenerative action produces the leading edge of the pulse shown in Fig. 1*c* and launches a step down the line. Equilibrium is maintained for twice the line's delay time, then the



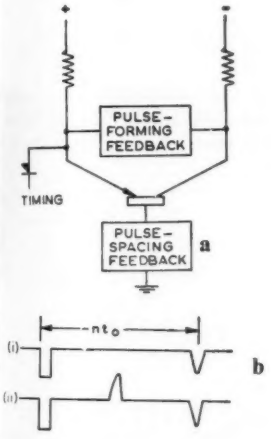
2 *Pulse generator with base resistance*
a Circuit.
b Waveforms.

reflected voltage step returns and drives the emitter negative. The transistor is cut off, the collector potential falls and the line is left with a negative charge. Current from the positive supply slowly recharges the line until

the initial condition is regained. The circuit shown in Fig. 1*b*, in which the feedback path is a tuned circuit, acts in a somewhat similar way, producing a pulse of length about $\pi\sqrt{(LC)}$.

Insertion of a resistance in the base lead (Fig. 2) increases the regeneration, permits a negative output pulse to be drawn, and facilitates triggering by short pulses, since the immediate shift of emitter potential on firing disconnects the trigger source. Also, negative trigger pulses may be fed to the base.

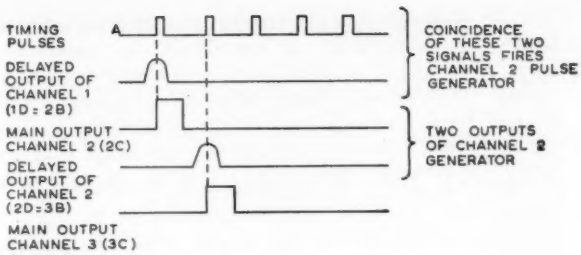
The slow recharging of the capacitor in the feedback path, by imposing a recovery time during which the circuit cannot operate, permits frequency division by a small factor. Stable division by large factors requires that the pulse interval should be determined by passive networks: a factor of 20–30 in one stage is readily achieved using an additional feedback network placed in the base lead (Fig. 3*a*). It consists of a short-circuited



3 *Frequency divider*
a Schematic.
b Gating waveform on base.

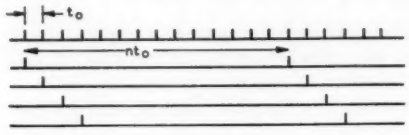
delay line which, driven by a negative output pulse from the transistor, returns a negative pulse to the base at multiples of four times the delay time (Fig. 3*b*, waveform ii). The transistor is biased so that it fires only on conjunction of one of these pulses with an input trigger pulse—not necessarily the first conjunction, since the recovery time may be chosen to fall between the (r-1)th and the rth, so reducing the delay time required to $r/4$ of the pulse interval (r is usually 2 or 3).

In transmission systems, where the time position allotted to each channel is permanent, several generators may be arranged in a ring, each being triggered only on conjunction of a timing pulse from a common source with a gating pulse obtained by delaying the output of a preceding stage (Fig. 4). Switching, on the other hand, requires the arbitrary assignment of various signals to various time positions. The divider circuit can be used to generate a pulse train at an assignable time position, since a divider by n has n possible phases of operation (Fig. 5). It requires the pulse from an external source to define the allotted position, which it then retains until it is deliberately cleared.


TIMING PULSES
A
DELAYED OUTPUT OF CHANNEL 1 (1D = 2B)
MAIN OUTPUT CHANNEL 2 (2C)
DELAYED OUTPUT OF CHANNEL 2 (2D=3B)
MAIN OUTPUT CHANNEL 3 (3C)
COINCIDENCE OF THESE TWO SIGNALS FIRES CHANNEL 2 PULSE GENERATOR
TWO OUTPUTS OF CHANNEL 2 GENERATOR

4 *Pulse sequence control*

A generator with a range of assignable time positions, together with a pulse modem as described in the companion papers reviewed on p. 255, forms a time-division selector switch which is a good analogue of a normal rotary switch in that it provides a low-loss 2-way connection; it is self-holding, retaining the position to which



5 *Interlacing of pulse trains*

it has been set; and it corresponds to a complete selector, not (like a simple electronic switch) to just a pair of contacts. 621.373.43 : 621.395.43

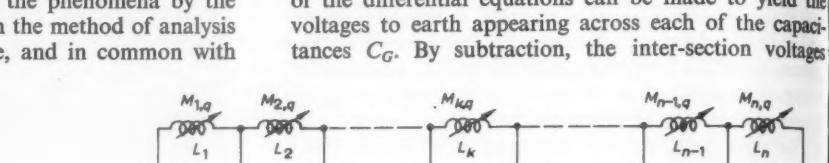
Analysis of Transformer Impulse Voltages by Digital Computer

A short review of a Supply Section paper (No. 2452) entitled 'A Method of Analysis of Transformer Impulse Voltage Distribution using a Digital Computer', by Beryl M. Dent, M.Sc., E. R. Hartill, B.Sc.(Eng.), Associate Member, and J. G. Miles, B.Sc.(Eng.), Associate Member. The paper was published individually in December 1957, and it will be republished in Part A of the Proceedings. The authors are with the Metropolitan-Vickers Electrical Co.

WITH THE INCREASING NEED FOR ECONOMY IN THE DESIGN of high-voltage power transformers it is useful to be able to predict at the design stage the impulse-voltage distribution throughout the winding. An accurate knowledge of these voltages is essential if the amount of insulation is to be kept to a minimum.

The pioneer work carried out at the laboratories of the E.R.A. and elsewhere has led to a better understanding of the complex phenomena involved, but even so, a complete design calculation by these methods is very lengthy and of doubtful accuracy. Routine design is therefore usually based on the initial (or capacitance)

voltage distribution, which can easily be calculated and which can subsequently be correlated with recurrent-surge oscillograph tests and actual impulse tests at high voltage. More recently Rudenberg and Norris have given a good physical explanation of the phenomena by the travelling-wave theory. Although the method of analysis is simple, it is still approximate, and in common with previous theories it cannot take precise account of non-uniformity or of the mutual inductance between winding sections or of the effect of chopped waves.



1 *General equivalent circuit for a transformer winding divided into n divisions*

The mutual inductances are denoted $M_{k,q}$, where q varies from 1 to n and $q \neq k$.

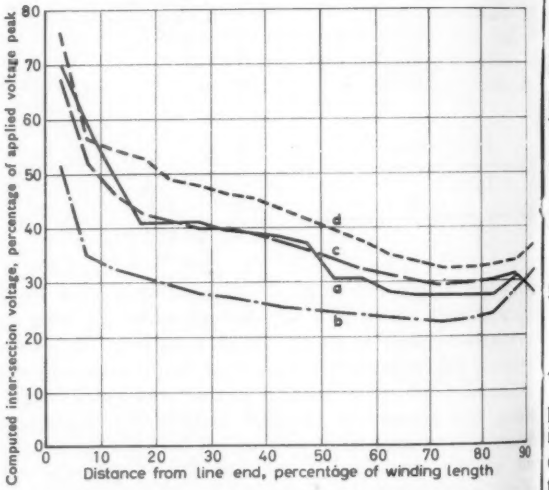
Abbetti in America has recently claimed that sufficient accuracy for design purposes can be obtained by means of recurrent-surge oscillograph tests on an electromagnetic scale model of the proposed transformer. This method, however, has the disadvantage that an expensive model has to be built; and it is difficult to see how sufficient capacitors can be connected to the model to represent the calculated inter-turn capacitances accurately.

Other workers in America and Switzerland have used the equivalent-circuit approach, in which the distributed series and ground capacitances and self-inductances present in the transformer are lumped into a ladder type of network. The actual values of these distributed constants can, in some instances, be calculated by digital computers, and the resulting network equations solved experimentally on electronic analogue computers.

In their own work the authors have aimed at eliminating tedious experimental work. The winding constants are first calculated from conventional formulae, and the equivalent network equations are solved rapidly and completely by means of a high-speed digital computer. The method takes account of mutual inductances, uniform or non-uniform windings, and also the full and chopped waves used in the impulse test.

Fig. 1 represents a non-uniform transformer winding, and indicates how the distributed winding constants are arranged in sections to form a ladder network. The applied voltage $v(t)$ gives rise to the indicated mesh currents, and the differential equations with respect to time are written down for each mesh. The limit on the number of meshes was imposed by the computer, since it could only conveniently solve a maximum of forty simultaneous differential equations. The maximum number of winding sections was therefore limited to twenty, which was considered adequate to represent any type of winding. The grouping of the sections can be varied at the discretion of the designer, so that significant portions of the winding (e.g. reinforced end turns) can be examined in detail, while less significant portions are grouped together. By suitable manipulation, the solution of the differential equations can be made to yield the voltages to earth appearing across each of the capacitances C_G. By subtraction, the inter-section voltages between individual winding sections C_S can then be determined.

Curve *c* of Fig. 2 shows the computed inter-section voltages plotted against winding length for an experimental three-phase transformer having a uniform winding. These agree reasonably well with curve *a*, which shows the corresponding voltages as measured by the recurrent-surge oscillograph. Curve *b* shows the error incurred by neglecting the inter-turn capacitance, and in this respect any uniform winding must necessarily be represented by a non-uniform equivalent circuit. Theories based on uniformly distributed equivalent-

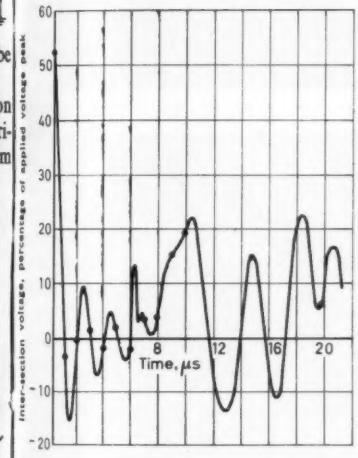


2 *Maximum inter-section voltages throughout winding*

a Measured.
b Calculated; neglecting inter-turn capacitance.
c Calculated; including inter-turn capacitance.
d As for **c** but with C_{G1-2} twice calculated value.

circuit constants cannot therefore be expected to give the correct results even for a uniform winding.

The transformer designer usually requires a curve of inter-section voltages versus winding length, similar to that in Fig. 2. However, in developing the present method, it was essential to plot inter-section voltages versus time for comparison with recurrent-surge oscillograph results. Fig. 3 shows the computed inter-section voltage across the first three winding sections, while the points represent check values calculated by Lewis's method.* The hand calculation of these few points was very laborious, and it is seen by comparison that some of the voltage peaks have been missed owing to the relatively large intervals of time between successive points. A digital computer is therefore essential if accurate calculations are to be made at sufficiently small intervals of time. Mutual inductances were neglected in Fig. 3, since Lewis's method does not include their



3 *Calculated voltage across first three winding sections*
Mutual inductances neglected. Points indicate results obtained by Lewis's method.

precise effect, but it is shown in the paper that mutual inductances must be included if correct results are to be obtained. Their effect is to steepen the front of the wave travelling down the winding, thereby giving rise to inter-section voltages which are higher than those predicted by Lewis's method.

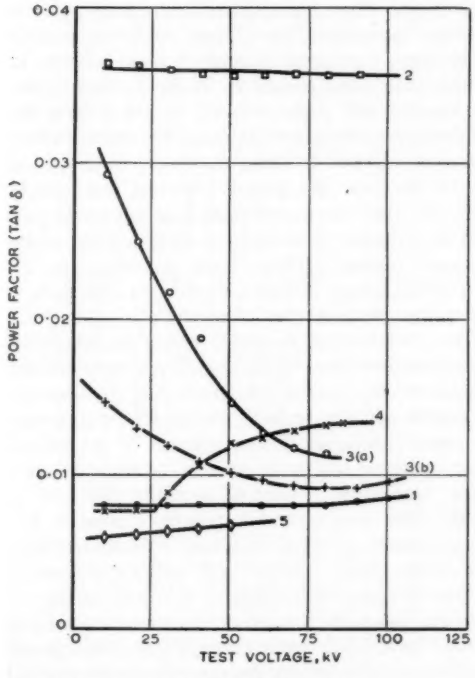
The method described forms a basis for the routine design calculation of transformer impulse-voltage distributions. Future developments will be directed towards shortening the present computation time of 2h 13min. This may be done by using a faster computer, and by arranging for the maximum voltages only to be printed out. Non-uniform windings with tappings will also be investigated with particular reference to more representative values of the winding constants. 621.314.2.015.33

* Lewis, T. J.: 'The Transient Behaviour of Ladder Networks of the Type representing Transformer and Machine Windings', *Proceedings I.E.E.*, Paper No. 1691 S, October 1954 (101, Part II, p. 541).

H.V. Bushings after Long Service

A short review of a Supply Section paper (No. 2473) entitled 'Laboratory and Field Tests on 132 kV Condenser Bushings', by J. L. Douglas, B.Sc.(Eng.), Associate Member, and A. W. Stannett, B.Sc.(Eng.), Associate Member. The paper was published individually in January 1958, and it will be republished in Part A of the Proceedings. The authors are at the Central Electricity Research Laboratories.

THE MAJORITY OF 132 KV CONDENSER BUSHINGS WHICH have been in operation on the Grid system for about twenty-five years have, in general, given excellent service, but there have been occasional failures. To prevent breakdowns in service, a laboratory investigation was undertaken on a number of 132 kV bulk-oil circuit-breaker bushings of the condenser type, with the object of establishing reference test methods. The measurements were extended to the field, and a large number of bushings were tested *in situ*. The deterioration of old bushings



1 *Typical power-factor/voltage curves*

only has been investigated, but the results are applicable to all types of condenser bushing.

From detailed laboratory investigations, it has been found that measurement of power factor and capacitance over a voltage range up to working voltage yields comprehensive information about the condition of the bushing.

2 *Erosion and puncture at badly overlapped foil end*

There are five distinct power-factor/voltage characteristics, as shown in Fig. 1, and by dissection of typical bushings it has been found that each characteristic shape is associated with a particular defect.

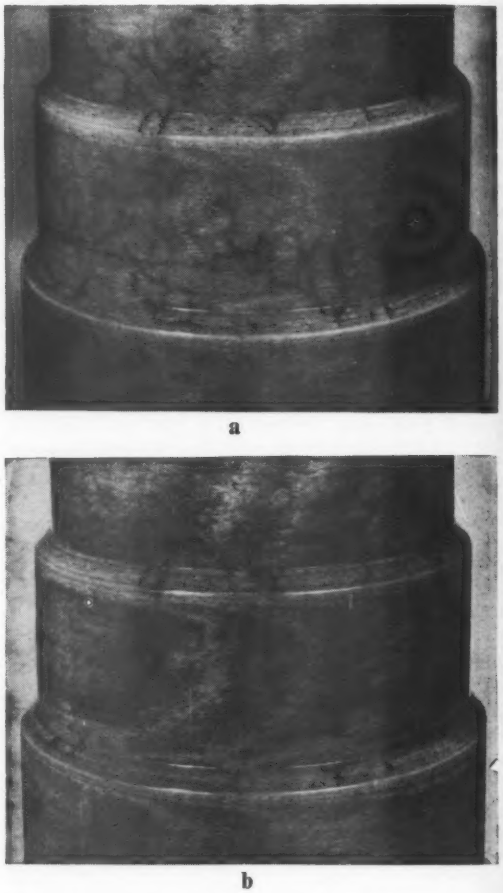
Curve 1 is the flat characteristic typical of a new bushing, where the power factor 'knee' is above working voltage. The high, level power factor of curve 2 is due to a skin of low insulation resistance at the surface of the synthetic-resin bonded paper, caused by water penetration from damp oil. Moisture may also be absorbed into solid insulation exposed to the atmosphere by a low oil level, but in this case the power factor is not usually affected because there is no complete low-resistance path to earth. The presence of moisture in the synthetic-resin-bonded paper causes surface tracking, although the nature of the tracking is different in the two instances.

The drooping power-factor characteristic of curve 3 is caused by a carbon path, either where an insulating section has punctured (curve 3*a*) or where a poor contact exists at a buried foil (curve 3*b*). In the first instance the bushing capacitance will be high, owing to the puncture of one or more condenser layers, whereas in the second instance the bushing will have normal or slightly lower capacitance. Generally, insulating sections puncture at the foil ends, after a slow erosion process caused by discharges in air spaces; a typical puncture is shown in Fig. 2.

The low 'knee' point of curve 4 is well known and is an indication of voids discharging at working voltage or less. These air spaces in condenser bushings are usually thin but may have large areas and are generally caused by poor adhesion of a foil to the synthetic-resin bonded paper. In the bushings examined there was little evidence to suggest that failure of an insulating section was likely as a result of these large thin air spaces.

The power-factor curve which rises steadily with voltage (curve 5) is found to be associated with oil penetration into the bushing. The electrical performance of a bushing is largely unaffected by this defect, but it would be weaker mechanically and may be less effective as an oil barrier.

In addition to Schering bridge measurements, other tests have proved useful for laboratory investigations. Radiography enables misplaced foils, cracks and built-up insulation to be detected and located, and infra-red photography can detect tracking below the insulation surface (Fig. 3).



a

b

3 *Tracking below the surface of a bushing*
a Direct light. b Infra-red light.

A portable Schering bridge, adequately screened for tests on earthed samples and operating up to 30 kV, was constructed for site measurements on installed oil-circuit-breaker bushings. The two main sources of error in such bridge measurements, namely, stray capacitance from high-voltage connections to earth and effects of extraneous electric and magnetic fields, can be readily eliminated.

The measured power factor of an installed bushing includes contributions from other components such as porcelains, explosion pots, breaker oil and operating mechanism, as well as the condenser parts. These items affect the power factor to such an extent that absolute values are of little importance, and it is necessary to

observe change of power factor with voltage over the range 5–30 kV. Thus, only the power-factor characteristics of curve 3 can be determined by means of the portable Schering bridge. In order to detect damp bushings, measurement of insulation resistance is essential, and this has been found to be an extremely sensitive method of detecting moisture in the synthetic-resin bonded paper or in the oil.

Capacitances of bushings tested in the field are appreciably higher than laboratory values, owing to stray capacitances to the earthed tank. Since these capacitances vary from breaker to breaker, it is impossible to fix definite rejection limits, and it is necessary to look for an increase in capacitance with age.

As a result of site tests on over 1 600 oil circuit-breaker condenser bushings, approximately 4% have been removed from service and another 3% classified as being in doubtful condition. The large majority of the rejected bushings had punctured sections due to discharge erosion, whilst a few were removed because of water penetration into the synthetic-resin bonded paper. It is considered that these two defects may lead directly to breakdown. Deterioration of connections to buried foils, formation of voids or cracks, or penetration of oil are not considered to be serious enough to warrant removing the bushing from service. They are taken as indications that the next stage of deterioration—puncture of a section—may occur in subsequent years. For these reasons, a combined insulation-resistance capacitance test set has been developed for the site testing of condenser bushings.

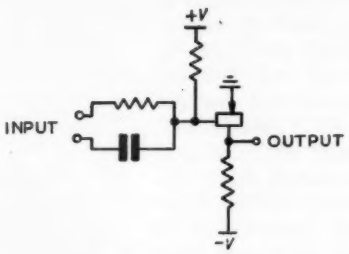
It is concluded that annual insulation resistance measurements and inspection of oil levels will detect the conditions which lead to surface tracking, whilst measurements of capacitance will detect punctured sections.

621.315.626.3

Basic Transistor Circuit for Digital Computers

A short review of a Measurement and Control Section paper (No. 2585) entitled 'A Basic Transistor Circuit for the Construction of Digital-Computing Systems', by P. L. Cloot, M.Sc.(Eng.). The paper is published this month in Part B of the Proceedings. The author is with the Metropolitan-Vickers Electrical Co.

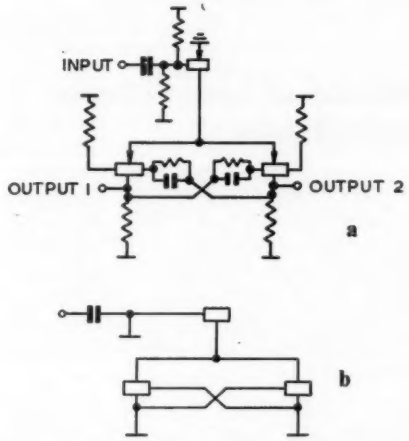
IN THE RUSH TO BUILD FASTER AND BETTER DIGITAL-computing systems, the fact is sometimes overlooked that there is a large field of application for computers in which reliability and simplicity are far more important than speed. In many industrial control and monitoring systems, a digit rate of a few kilocycles per second is all that is required, and some traffic control schemes, for example, use digital circuits operating at 50 c/s. By using the basic circuit shown in Fig. 1, comprising a transistor,



1 *Basic circuit*

a capacitor and three resistors, any of the logical or timing circuits required in a digital computer can be constructed economically, although the speeds obtainable with more complex circuits cannot be realized. The use of a transistor instead of a diode for logical functions may at first sight appear extravagant, but, while the initial component cost may be greater, the ease of system design more than compensates for this.

Three simple rules restricting the interconnection of basic circuits are given in the paper, and if these are followed a reliable system can be designed. These rules take account of such factors as spread in transistor parameters, component tolerance, and supply-voltage and temperature variations. Calculations are made for a typical low-frequency junction transistor, and a description is given of an experimental logical system consisting of 184 basic circuits. This system uses many well-known computer circuits, all constructed from the



2 *Scale-of-two circuit*
a Actual circuit. b Simplified schematic.

basic circuit shown in Fig. 1, and as an example a scale-of-two circuit formed by three basic circuits is shown in Fig. 2*a*. Since one circuit is used throughout, the circuit diagrams may be simplified to a considerable extent, and the diagram necessary to specify the scale-of-two circuit completely is shown in Fig. 2*b*.

The use of only one basic circuit enables a new

technique to be used for the mechanical construction of a computer: all components can be mounted on identical plug-in printed circuits, and all the interconnections carried out on the socket terminals. The experimental logical system described has been constructed using this technique, each plug-in unit containing two basic circuits. After such a machine has been designed, most of the work in its construction consists of the manufacture of a number of identical plug-in units and the interconnection of the socket terminals. It is suggested at the conclusion of the paper that the use of printed wiring for these connections also would make the machine very easily reproducible.

This method has since been developed, and a computer which consists entirely of identical plug-in units and printed interconnecting wiring is shown in Fig. 3. This machine has a built-in programme for binary/decimal conversion, with a maximum capacity of 10 binary digits. It has been constructed for demonstration purposes, and hand switches and indicator lights are therefore used as input and output equipment. All other components are contained on 88 identical plug in units, each containing four basic circuits, and the only external connection required is one to the power supply.

3 *Demonstration computer*

621.374.32 : 681.142 : 621.382

Phase Variations of Long-Distance 16 kc/s Transmissions

A short review of a Radio and Telecommunication Section paper (No. 2562) entitled 'Phase Variations of 16 kc/s Transmissions from Rugby as received in New Zealand', by D. D. Crombie, M.Sc., A. H. Allan, B.E., Associate Member, and Miss M. Newman, B.Sc. The paper is published this month in Part B of the Proceedings. The authors are at the Dominion Physical Laboratory, Lower Hutt, New Zealand.

THE USE OF VERY-LOW-FREQUENCY (10–30 kc/s) TRANSmissions for long-distance radio communication was largely abandoned in the late 1920's following the discovery that high-frequency transmissions could usually provide the same, or better, service at lower cost. However, interest in the v.l.f. band has increased in recent years. This is because the use of these frequencies offers the possibility of reception by submerged submarines, and is also likely to make practicable navigational aids of much greater range than is possible at higher frequencies.

The paper gives the results of about a year's observations in New Zealand of the diurnal phase variation of the highly stable 16 kc/s transmissions from Rugby. The results confirm that propagation conditions at 16 kc/s are much more stable than at high frequencies, and may be very suitable for the dissemination of a single standard frequency over the whole of the earth.

The measured diurnal phase variations show seasonal differences. It has been found that these can be explained if it is assumed that propagation is by the first-order transverse-magnetic waveguide mode, of the type which can exist between parallel metallic planes. The diurnal phase change is then due to the reduction in height of the ionosphere which occurs when it is illuminated by the sun. The measured phase variation using the metallic sheet model gives a change in the height of the ionosphere of from 70 km during the day to 80 km at night, which is less than has been deduced by other workers over much shorter paths. This discrepancy is thought to be due to the imperfections of the metallic sheet model. It is believed that the simple waveguide approach will enable the diurnal phase variations over other paths to be predicted with considerable accuracy.

621.396.812.4

SYNOPSES OF PAPERS

Thermionic and Cold-Cathode Valves

A synopsis of a review of progress (paper No. 2560) with the above title, by W. H. Aldous, B.Sc., Associate Member. The review is published this month in Part B of the Proceedings. The author is with the General Electric Co.

THIS PAPER REVIEWS THE PROGRESS MADE IN THE DESIGN and manufacture of certain classes of valves since the immediate pre-war years.

In the field of receiving valves the major outward sign of progress has been a steady decrease in size; modern miniature valves on button bases have a volume about one tenth that of their earlier counterparts. At the same time the greatly increased precision in the manufacture and assembly of the internal structure has given improved electrical characteristics. Smaller size for a given power level enables valves to work at higher frequencies, but involves an increase in operating temperature which must be accommodated by improvements in materials.

The use of borosilicate glass for the envelopes of low-power transmitting valves has enabled their size to be reduced with consequent improvement in performance. Noteworthy accomplishments in this field are the double tetrodes with a common cathode. The overall efficiency of cooled-anode valves has been improved by the successful use of carburized-thoriated-tungsten filaments, which require about one third of the heating power of the former pure tungsten filaments. Major progress in design has produced tetrodes to give tens of kilowatts of power at frequencies around 1 Gc/s.

Greater use is being made of the rare gases, such as xenon, in hot-cathode gas-filled diodes, thus avoiding the narrow temperature limits of operation associated with mercury vapour. The war-time development of mercury thyratrons as high-power switches in radar sets has been followed by the evolution of even higher-powered hydrogen-filled valves for the same purpose, their success being largely due to the use of a replenisher to maintain the correct gas pressure during life.

Cold-cathode diodes have been developed with very constant voltage drop to provide good reference voltages for stabilizers. For trigger devices the cold cathode has the advantage in switching circuits that no current need be consumed during standby periods. Multiple trigger tubes with cold cathodes find wide use in high-speed counters. 621.385.1 : 621.387

Distortion in F.D.M.—F.M. Systems

A synopsis of a Radio and Telecommunication Section paper (No. 2565) entitled 'Distortion in Frequency-Division-Multiplex F.M. Systems due to an Interfering Carrier', by R. G. Medhurst, B.Sc., Mrs. E. M. Hicks, B.Sc., and W. Grosset, Associate Member. The paper is published this month in Part B of the Proceedings. The authors are with the General Electric Co.

A THEORETICAL INVESTIGATION HAS BEEN MADE OF THE distortion produced in f.m. frequency-division-multiplex trunk radio systems by the simultaneous reception of a wanted and an unwanted carrier, not necessarily identical in frequency. This form of disturbance can occur both between different systems and within a single system.

It is found that, unless there is substantial failure of the receiver limiter action, the distortion generated in a particular channel is accurately proportional to the relative level of the interfering carrier. Thus, it is possible to plot curves of distortion in the worst channel against frequency separation of wanted and unwanted carriers, from which, for a given separation, a permissible level of interfering carrier can be deduced. Curves are presented for 240- and 600-channel systems when the interfering carrier is either modulated or unmodulated. Numerical results are shown for various carrier-frequency separations that can arise under the C.C.I.R. frequency plan for systems of six r.f. channels each carrying 600 speech channels.

The distortion due to this mechanism can be divided into intelligible and unintelligible crosstalk. Reasons are given for the expectation that the former will not normally be important. 621.395.43 : 621.396.813

Atmospheric Radio Noise

A synopsis of a Radio and Telecommunication Section Paper (No. 2619), entitled 'Atmospheric Radio Noise at Frequencies between 10 kc/s and 30 kc/s', by J. Harwood, M.A., Ph.D. The paper is published this month in Part B of the Proceedings. The author is at the Radio Research Station, Department of Scientific and Industrial Research.

MEASUREMENTS OF THE CHARACTERISTICS OF VERY-LOW-frequency atmospheric noise in Southern England have been made with automatic equipment during the last few years. The results are described in terms of statistical parameters of the envelope at the output of a narrow-bandwidth receiver (300 c/s between 3 dB points).

The average voltage of the envelope, recorded via an integrating circuit with equal charge and discharge time-constants of 8 sec, showed short-term fluctuations of about 5% and clear diurnal and seasonal variations.

The r.m.s. voltage, deduced by integration of measured amplitude probability distributions, varied between 4 and 8 times the average voltage; the values were very dependent on the incidence of large infrequent pulses.

The noise was always much more impulsive than fluctuation noise. The structure of the envelope was described by two forms of distribution, one being the amplitude distribution of the peaks of pulses, and the other the conventional amplitude probability distribution of voltage. The former was represented by a simple power-law function of voltage involving two parameters, the average voltage and the power-law index. The latter was represented by another simple function involving two similar parameters. The character of the noise was always approximately the same in spite of substantial changes of average voltage from time to time.

Variations of the intensity and structure with frequency and bandwidth were examined. 621.396.822 : 621.317.34

SCATTERING OR NOT? 621.396.8

A symposium on long-distance propagation at frequencies above 30 Mc/s was held in the Institution building at Savoy Place, London, on the 28th January 1958. This article describes the proceedings at the three sessions, at which twenty-two papers were read and discussed. The papers and discussions will be published at the end of May in a Supplement (No. 8) to Part B of the Proceedings.

An all-day symposium, organized by the Radio and Telecommunication Section, was held on the 28th January for the presentation of papers describing recent British contributions to the study of long-distance propagation at frequencies above 30 Mc/s. This is a subject of considerable interest, for two reasons. In the first place it has been found possible, by the use of high radiated powers and directive transmitting and receiving aerials, to communicate over distances of about 1 000–2 000 km on frequencies exceeding the maximum usable frequency (as normally determined by ionospheric characteristics); and it is known that the transmission occurs via the E region of the ionosphere by a mode of propagation depending upon fluctuations of the electron density in this region. Ionospheric 'scatter' propagation, as it is called, is of particular interest in the frequency band of approximately 25–70 Mc/s, and the morning session of the symposium was devoted to a consideration of eleven papers on this topic.

The second aspect of long-distance propagation at these very high frequencies is concerned with tropospheric influences on transmission—the received signal is subject to the vagaries of the weather—and this was the theme of the papers at the afternoon and evening sessions. It has been known for some thirty years that the transmission of very short waves is not necessarily limited to horizon ranges, as had originally been anticipated. The first examples of beyond-the-horizon propagation of such waves were clearly connected with the existence of abnormal conditions in the troposphere, conditions now generally described by the term *super-refraction*. More recently, with the use of greater effective radiated powers, it has been found that at all times the signal strength well beyond the horizon is much greater than early theories would have suggested. The mechanism responsible for this phenomenon is generally supposed to be some form of scatter propagation dependent upon ever-present fluctuations of the refractive index of the lower atmosphere. Long-distance tropospheric propagation, whether due to abnormal refraction or to scattering, is primarily of interest in the frequency range 30–30 000 Mc/s; though practical applications of scattering are likely to be restricted to the frequency range 300–5 000 Mc/s, and to distances of up to perhaps 1 000 km.

Ionospheric Propagation

The morning session began with an introductory paper by F. A. Kitchen and G. Millington, which gave a survey of recent experiments on ionospheric forward-scatter propagation, with special reference to observations in England on transmissions from Gibraltar. This was followed by a number of papers on one or other of the special aspects of these transmissions.

It is essential that high-gain aerials should be used on ionospheric scatter links, and further that these aerials should be sited so that the beams from the transmitting and receiving terminals overlap at the right place in the E region of the ionosphere. These matters were considered in papers by D. H. Shinn and by E. Fitch and R. Ruddleston. An analysis of the detailed character of the signals received in this country from Gibraltar was described by G. A. Isted, who also discussed the effects of various forms of interference on the reception of scatter signals. A further paper on the nature of the signals was presented by D. Williams; and the same author, in collaboration with P. H. Cutler, gave an account of a scatter-signal analyser used in this work.

The general characteristics of the scatter signal show the presence of a permanently and rapidly fading background upon which there are frequently superposed relatively large bursts of signal lasting for periods of up to a minute or so. There has been for some time much argument concerning the mechanisms responsible for these two components, particularly that giving rise to the background signal. Although the papers so far mentioned provided valuable new information, they did not in fact help greatly in the solution of these problems. Whilst most workers in this field have considered that the short bursts of enhanced signal are due to reflections from the ionized trails of relatively large meteors, another view is held by G. A. Isted, namely that many of these bursts are caused by reflections from transient patches of ionization in the E region produced by upward electrical discharges from thunderclouds. An investigation described by G. S. Kent, in which observations were made on the short bursts of signal received at Cambridge from the television transmitter at Kirk o'Shotts, has now provided strong evidence that the majority at least of the bursts must be attributed to reflections from meteor trails.

The two main rival theories concerning the background signal have supposed that it is due either to scattering caused by turbulence in the lower E region, or to the integrated effect of reflections from the trails of the multitude of sporadic and relatively small meteors known to be continuously entering the atmosphere. Papers presented at the symposium by R. W. Meadows and W. C. Bain brought fresh light to bear on this argument. These papers described directional measurements, using the Gibraltar transmissions, on the large signal bursts

and on the background signal. As a consequence of the scattering process, the radiation arriving at the receiving point is spread over a small range of angles, and it has been found that the mean bearing of the energy distribution of the background signal varies with time of day in much the same manner as does the direction of arrival of reflections from the larger meteors. This provides a clear indication that small meteors contribute considerably to the background signal for much of the time; though, since the mean bearing of this signal relative to the great-circle path between transmitter and receiver is zero in the middle of the day, a propagation mechanism depending upon the total electron density of the E region and upon turbulence is certainly not excluded at such times.

The final paper of the first session, by P. J. Brice, was concerned with the interference likely to be caused and experienced by ionospheric scatter systems when sporadic-E ionization is prevalent. Such trouble may arise fairly often at frequencies appreciably less than about 50 Mc/s, and may be a serious matter at times in view of other services, such as television, operating in the same frequency band.

A lively discussion, introduced by W. J. Bray, was provoked by the papers presented at the morning session; and the arguments advanced by B. H. Briggs, G. A. Isted, G. Millington and J. A. Saxton showed that not everyone is yet convinced that the problem of the propagation mechanism is finally solved. Other matters discussed were the manner in which the scattered power varies with frequency, and, particularly by E. Fitch and H. G. Hopkins, the degree of reliability in communication which may be achieved in view of the various sources of interference known to exist. On this last point, mention was made of the delayed signals which can occur when the density of ionization in the F2 region is high; and evidence was produced that round-the-world transmission had occurred with transmissions from Gibraltar on 37 Mc/s. W. J. Bray expressed the view that applications of ionospheric scattering to communication, at any rate in the civil field, seem to be few, since the transmission capacity is small—limited in fact to only a few telegraph channels—and the quality of telephony is poor. He added that the main applications would appear to be in the field of military and strategic communication systems.

Tropospheric Propagation

After an interesting introductory paper by G. A. Isted describing some of the pioneer work on tropospheric wave propagation carried out by G. Marconi, the remainder of the afternoon session was concerned with various aspects of the propagation of metre waves through the troposphere to points well beyond the horizon. In this subject, interest is focused mainly on either the strongest fields—reached for only a small fraction of the time—or on the relatively weak residual fields present for the whole of the time. The first of these features is important for the bearing it has on the problem of interference between transmitters operating in the same or adjacent frequency channels, and it was considered in papers by R. A. Rowden, L. F. Tagholm and J. W. Stark, and by J. K. S. Jowett. The two other papers in this session, by B. J. Starkey, W. R. Turner, S. R. Badcoe and G. F. Kitchen, and by F. A. Kitchen, E. G. Richards and I. J. Richmond, described investigations of the residual long-distance tropospheric fields, and there was a divergence of opinion on the mechanism of propagation involved. B. J. Starkey and his colleagues maintain that their results, and other experimental data, too, can be explained more readily on the assumption that propagation occurs over such distances by reflections from discrete discontinuity layers in the troposphere up to the height of the tropopause, rather than by scattering depending upon ever-present turbulent fluctuations of the atmospheric refractive index, which is the other principal contending theory. On the other hand, F. A. Kitchen and his colleagues conclude that it is not yet possible to determine whether the residual signal is due entirely to either of these two processes.

In introducing the evening session of the symposium, also on tropospheric propagation but mainly at centimetre wavelengths, J. A. Saxton discussed the question 'What constitutes scattering?' and criticized some of the restrictive ideas which seem to have become connected with this subject. Experimental studies of beyond-the-horizon propagation at 3 480 Mc/s and 858 Mc/s were described respectively by B. C. Angell, J. B. L. Foot, W. J. Lucas, and G. T. Thompson, and by G. C. Rider. These papers covered such topics as the variation of the characteristics of the received signal with time and with the weather, and also the requirements which the terminals should satisfy for the best results to be achieved.

Two papers on propagation over entirely sea paths were contributed by W. R. R. Joy. An important feature of this work is the discovery that, although the signal attenuation rate with increasing distance at wavelength of 3 cm is similar to that expected for a scattered field, the average level of the signal is significantly less than that which would be predicted from scatter theories based on the turbulence hypothesis. The paper on propagation at a wavelength of 10 cm was of particular interest in that it amplified previous accounts of the pioneer work in this field of the late E. C. S. Megaw.

The last two papers of the final session were concerned with the theory of tropospheric scatter propagation; and it was evident that both of the authors, M. A. Johnson and E. G. Richards, favoured turbulent scattering as an explanation of the residual fields observed at points well beyond the horizon.

The discussions on tropospheric propagation were opened in the afternoon by R. L. Smith-Rose, and in the evening by G. Millington. It was inevitable that, as at the morning session, there should be much argument about the physical processes involved. There is no doubt that the highest long-distance signals are due to super-refraction in the atmosphere in one form or another, including well-defined elevated reflecting layers, which

are well known to have an important influence on metre waves in particular: but whether 'blobs'—as in the turbulence theory—or a number of less well-defined layers are responsible for the scattered field is obviously a matter of some dispute. Views on this subject were expressed by G. Millington, F. A. Kitchen, J. K. S. Jowett and J. A. Saxton.

Several speakers in the discussions dealt with the application of tropospheric scattering to communication. On the one hand it was suggested by H. Stanesby that, for communication within any one country, tropospheric scatter links are unlikely to be able to compete with conventional radio relay systems in channel carrying capacity; whilst N. Knudtzen said that such scatter links were already in use in Norway for telegraphy and telephony, though apparently only for military communications. A. J. Buxton and M. O. Felix drew attention to the advantages to be gained by the use of frequency compression with frequency-modulation systems, though other speakers were somewhat sceptical about the claims made. On the issue of practical applications there were several comments on the difficulties caused by reflections from aircraft flying in or near to the aerial beams.

Monsieur P. B. David, a representative of S.H.A.P.E., said that the information provided by the symposium would be of great value to all the European nations.

The day's proceedings were summed up by R. L. Smith-Rose, who emphasized that, whilst experimental investigations of propagation served well to assist the engineer to plan practical communication systems in areas where the research had been carried out, it was not always easy to use the same data for engineering purposes in different geographical regions. It is clearly not practicable always to make pilot investigations before every engineering application, and the aim must therefore be to achieve the best fundamental understanding of the propagation phenomena from those experiments which are made, and thus as far as possible to ease the task of extrapolation.

There is no doubt that the symposium was a most successful occasion. It was very well attended, and there were visitors from several European countries and from Canada. The wealth of discussion and interest shown certainly justified the belief of the Radio and Telecommunication Section Committee that the organization of such a symposium would be widely appreciated. J. A. S.

OBITUARY

JAMES PRESTON

James Preston, who was born on the 8th February 1893, died on the 19th January 1958. His technical education was received by part-time study at the Royal Technical College, Salford, and St. Anne's Technical College, while he was an apprentice in the General Electrical Co., Salford, Mather and Platt, Manchester, and the Salford Electricity Department.

On the completion of these apprenticeships in 1914 he joined the Army and served with the Royal Field Artillery; but he was invalided out in 1917, suffering from mustard gas and shock. His war experiences produced a lasting nervous condition, which was sometimes very obvious and was a disability throughout his life.

In 1918 he returned to Salford in the capacity of switchboard attendant and after a short time he was transferred to the testing department as first test assistant. In spite of his disability he gradually rose to the position of Senior Assistant Engineer of the department and eventually became its chief. During the rapid expansion of the industry he developed the resources and techniques of the testing department to keep pace with the progress of the Salford undertaking. When the industry was nationalized in 1948, Mr. Preston was appointed Superintendent of Testing for No. 2 Sub-Area of the North Western Electricity Board and became responsible for the testing station established by the former Lancashire Electric Power Co. at Walkden and for the gradual transfer of the work from the other testing stations in the Sub-Area to Walkden.

In private life Mr. Preston was retiring and entered little into social activities, although his friendly manner was appreciated by those with whom he came into contact. He enjoyed a day at the seaside with his wife whenever the opportunity occurred, and their holidays were usually taken within easy reach of their home. It is unfortunate that one who had served the industry so faithfully throughout his working life, and carried a war disability for so much of it, should have died shortly before he was due to retire. He is survived by his widow.

Mr. Preston joined The Institution as an Associate Member in 1943 and was elected a Member in 1952. O. H.

WELLINGTON ERNEST GROVES

Wellington Ernest Groves, who died on the 30th January 1958, was born in Dorset on the 9th February 1869. He was educated at Wimbourne School and received his electrical training with Crompton and Co. He was appointed Mains Engineer to the Birmingham Electric Supply Co. in 1892, and held this position until he retired in 1932.

Mr. Groves was a gifted engineer and was responsible for the very large cable network developed by his undertaking over the years, including the rapid expansion during and after the First World War. His work involved designs for all voltages up to and including 33 kV, the latter being employed principally for conveying energy from the new generating stations at Nechells and, later, Hams Hall A, to major substations within the city.

The necessity for an eventual a.c. network was appreciated by him at an early stage, and many miles of four-core distribution cable were laid and run on direct current before the change to alternating current took place. His unremitting attention to work led to a breakdown in health and he was forced to take a three months' rest in 1924. A year or two after his return to duty it

became necessary to design a complete distribution network, largely by means of overhead lines, of which he had no previous experience, to supply the new area of over 100 square miles on the east side of the city that was allotted to his undertaking in 1926. By 1932, when he retired, supply had been provided to all principal centres of population in this area.

He invented the 'Groves Ohmmeter'; this was the subject of a paper entitled 'Localization of Faults on Low-Tension Networks', which was read before The Institution in March 1904. This instrument was very valuable for checking the instantaneous insulation resistance of d.c. networks and for the rapid detection of faulty lines.

Mr. Groves made a deep impression of rectitude and of almost ascetic devotion to duty on those who served with or under him. It was natural that an engineer of his unusual mentality should become the source of many stories and anecdotes, and over the years a constant stream of sayings, natural to him, yet extremely amusing to his staff, gave a sparkle and zest to the daily routine. His strict discipline and severity covered shyness and much kindness.

Mr. Groves was a keen churchman and a man of the highest principles, always putting service before self. His leisure hours were divided between the pleasures of literature, gardening, the solution of difficult acrostics, ornithology and the lore of the countryside generally. He founded the Birmingham and West Midland Bird Club, which, with over 500 members, is now the largest bird club in the country. With these diverse interests, his long retirement of twenty-six years was completely and satisfyingly filled. He is survived by his daughter, his son having been a victim of the First World War.

Mr. Groves joined The Institution as an Associate in 1895, and was elected an Associate Member in 1899 and a Member in 1910. He served on the Birmingham Local Section Committee 1905–8 and on the South Midland Centre Committee in 1921. J. G. G.

SIR JAMES SWINBURNE

Sir James Swinburne, BART., F.R.S., PAST-PRESIDENT, died on the 30th March 1958, about a month after celebrating his 100th birthday. He came of a well-known Northumbrian family. His father was a Captain in the Royal Navy, who on retirement lived for some years on a small island off the coast of North Scotland. James was born in Inverness on the 28th February 1858. He was educated at Clifton College and from there went to a locomotive works at Manchester. Later he went to a Tyneside firm and became interested in electrical work. Then he joined Swan's lamp works in Newcastle and helped start lamp factories in Paris and in Boston, Mass. When he returned to England he joined Hammond's lamp works; about 1885 he became technical assistant and, later, manager of Crompton's dynamo works. In this period he invented a watt-hour meter and designed his 'hedgehog' transformer. He was also a frequent contributor to the *Electrical Review* and began to attend the meetings of The Institution, of which he was later to become President.

The present writer remembers a meeting at the end of last century when a critic discussing a paper complained that the working drawing given of a ten-horse-power motor was very complicated; Swinburne defended the author by remarking that it was not one-tenth as complicated as the working drawing of a one-horse-power cart-horse—a typical piece of Swinburnian humour.

He himself contributed many papers to The Institution's *Journal*, including those on 'The Theory of Armature Reactions in Dynamos and Motors' (1890), 'Transformer Distribution' (1891), 'The Problems of Commercial Electrolysis (1892), 'New Incandescent Lamps' (1907) and 'How a Top Stands Up' (1915). His Presidential Address in 1902 was entitled 'Some Limits in Heavy Electrical Engineering'.

In 1899 he set up as a consulting engineer at 82 Victoria Street, and also began to give technical evidence in the High Court. Perhaps it was as a result of this work that, about 1902, he returned to the study of steam engineering, and, in 1903, read a paper before the British Association on an engineer's view of thermodynamics. In 1904 he published his book 'Entropy'. He was elected a Fellow of the Royal Society in 1906.

In 1902, on a visit to a patent agent's office, he was shown a synthetic resin which looked like 'frozen beer turned out of a tumbler'. It was said to be quite useless. It had been made by an Austrian chemist named Luft, who used the chemical reaction between phenol and formaldehyde described by Baeyer in 1872. Swinburne took a sample, tested its electrical properties, read up the chemistry, experimented on the reaction, and made more of the resin. He discovered solvents and noticed that it dried as a very hard lacquer. He thereupon humorously registered it under the name of Damard Lacquer. Apart from its use as a lacquer, the solid resin was an insulator, was non-inflammable and could be moulded; so Swinburne and Kingsbury (whom many senior members of The Institution will remember) formed a company for manufacturing separators for lead batteries. This was not a success, but in the meantime Swinburne had improved the resin by modification of the catalyst, and, in 1907, he applied for a patent. Later, it was found that Baekeland in America had anticipated Swinburne's patent by one day. After this, by tacit consent, the applications of the solid resin were produced in the United States by Baekeland and the liquid lacquer was made in England.

For the development of the business the Damard Lacquer Co. had been formed. Its headquarters were moved to Birmingham, the centre of the brass-finishing industries. Swinburne became Chairman. About 1914, a research department under Mr. H. V. Potter was started, and other phenolic resins were studied. The company flourished and, in 1926, Bakelite Ltd. was formed, with Swinburne as Chairman and Potter as Managing Director. During this period Swinburne read papers before the Faraday Society and was elected President of that Society from 1909 to 1911.

In 1934, Swinburne succeeded his cousin as ninth baronet (created in 1660), and, in 1948, he became Honorary President of Bakelite Ltd.

Sir James was an accomplished musician, and at his home in Bramham Gardens he built a large organ of which the manual was in the drawing-room and the bellows in the basement. Some of the longer pipes were bent horizontally along a ceiling, and on this instrument he played until he left the house. When nearing the age of 90, he declared that he must not become a cabbage and so started, as a hobby, the cleaning and mending of clocks and watches for his friends. This led him to study horology, and he wrote articles that appeared in the *Horological Journal*; indeed at 92 he published a small treatise on the mechanism of the watch and proposed a number of improvements. This is not surprising for his interests had always been wide. For instance, in 1924 he wrote a book entitled 'Population and the Social Problem', which stressed the importance of the 'principle of population'. Study of this, Swinburne felt, was the key to the abolition of poverty.

Sir James in person had an old-world courtliness, which, combined with a sense of humour almost puckish, and great skill as a raconteur, made him a delightful companion. Sir James and Lady Swinburne were a couple with unusual graciousness and charm. Up to the time of his death he enjoyed fairly good health and often went for a walk.

Swinburne was married twice, in 1886 to Ellen Wilson, by whom he had two sons, and in 1898 to Lilian, daughter of Sir Godfrey Carey. By his second wife, who survives him, he had two daughters.

On his 100th birthday the Council sent a letter of congratulations to Sir James, which was delivered personally to him by the writer of this memoir. There were tributes to him from the Royal Society and in the national and technical Press. *The New Scientist* published a long 'Profile' of him, the first time the series had included anyone of his generation.

Sir James was elected a Member of The Institution in 1885—his period of Corporate Membership of 73 years has never been equalled. He was President of The Institution 1902–3 and Honorary Editor of *Science Abstracts* 1898–9. He also served as President of the Plastics Institute 1937–8. W. H. E.

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MONOGRAPHS

The Circuit Theory and Calculations of Polyphase Induction Machines *Monograph* 304 U

N. KESAVAMURTHY, M.A., M.SC.(TECH.), *and* R. E. BEDFORD, B.SC., PH.D.

The paper examines in a systematic manner the nature of the various circuits and circuit parameters of both wound-rotor and squirrel-cage induction machines. From these the basic voltage and torque equations are deduced. Substitute variables are then introduced to enable the equations to be made to depend on the speed rather than the position of the rotor, thus making the differential equations linear with constant coefficients for the important case of constant angular velocity of the rotor.

In order that the theory formulated may be of value in practice, methods of evaluation of the various circuit parameters from the physical dimensions of the machine are developed. For these the existing methods available for conventional design constants have had to be considerably modified. The circuit parameters are computed for an actual machine and compared against test results.

The Response of a Network to a Frequency-Modulated Input Voltage *Monograph* 305 R

J. W. HEAD, M.A., *and* C. G. MAYO, M.A., B.SC.

If a voltage $v(t)$ is applied to a network of admittance* Y, the resultant current $I(t)$ can be obtained by three different methods:

(*a*) By symbolic calculus, in which an image or transform V of $v(t)$ is found and $I(t)$ is determined by applying the inverse transform to the product VY. This leads to difficulties in the f.m. case because V cannot be conveniently formulated.

(*b*) By the convolution integral derived from $v(t)$ and the response $y(t)$ of the admittance Y to unit impulse. The paper derives well-known formulae by this method, together with an additional formula applicable to a typical amplifier-discriminator system in which the distortion imposed by the admittance is separated from mere delay.

(*c*) By operational calculus, in which the admittance Y is regarded as an operator, a function of d/dt, and the input voltage $v(t)$ is the operand. The same formulae are derived more simply by operational calculus.

* Admittance may be generalized to transfer function.

The Editor regrets that Monograph 287 R was wrongly recorded in the February 1958 issue of the Journal. The correct title and synopsis are published below.

Microwave Aspects of Waveguides for Long-Distance Transmission *Monograph* 287 R

A. E. KARBOWIAK, PH.D., B.SC.(ENG.)

Principal microwave problems encountered in the design of long-range communication systems using waveguides are discussed. The reasons for choosing as the medium of transmission the circular waveguide excited in the H_{01}-mode are given, and means of bridging engineering difficulties are analysed in some detail.

In particular, it is shown that plain metal waveguides are not suitable for long-range application, unless the waveguide run is substantially straight. Practical waveguides, however, must be able to follow ground contour and other unintentional bends—a condition under which the performance of conventional waveguides is considerably degraded.

The problem of unintentional bends is analysed in detail using perturbation calculus and the concept of surface impedance. The formulae obtained lead to design criteria for waveguides which are free from the above restrictions. A number of suitable waveguides are introduced, and the proportions are chosen with the help of charts given in the paper. A circular metal waveguide coated with a thin skin of a dielectric is a possible solution.

Circular anisotropic waveguides are discussed at length and, among other designs, the helical waveguide of suitable proportions is shown to be another possible solution.

Numerical examples are given to illustrate the design approach and to contrast the performance of optimum designs with conventional waveguides. These examples also show that whereas the special waveguides can be bent—for example, to follow the ground contour—to a radius as small as 100 m (or even less) without causing any appreciable deterioration in their electrical performance, the conventional waveguides under similar conditions would be considerably degraded, even to the extent of being useless for practical applications.

PAPERS

Standardization of Control Facilities for the British Grid: Communications, Indications and Telemetering
Paper 2626 S: *Part A*

P. F. GUNNING

During 1932–57, different telephone, general indicating, and telemetering systems were used to control the British Grid. These systems served their purpose, but improvisations had to be made from time to time to cater for expansion of the Grid. Since 1938, the Grid has been operated as one interconnected system; it is now of 22 000 MW capacity and the rate of expansion shows no sign of diminishing. A readily extensible and standard system became necessary, and in 1950 the then British Electricity Authority embarked on a programme to re-equip about 300 stations, 8 Grid Control Centres and the National Control Centre with a 'standardized system' which provided many new features.

The standardized system was developed by certain telephone manufacturers in consultation with the Authority. The paper gives a full description of the facilities it provides and also the reasons why with few exceptions rented Post Office circuits are used for the control networks. A brief description is included of control facilities afforded by switchgear-reclosing equipment provided at unattended stations controlled by the standardized system.

The principal design features of the system are described in the companion paper (see next column).

To be read on the 28th May 1958

The Development of Communication, Indication and Telemetering Equipment for the British Grid
Paper 2627 S: *Part A*

G. A. BURNS, F. FLETCHER, M.B.E., C. H. CHAMBERS, *and* P. F. GUNNING

The development of a 'standardized system' of communication, indication and telemetering to control the British Grid was started in 1949 by certain telephone manufacturers and the then British Electricity Authority. The system is now in full operation in all Grid Control Areas of the Central Electricity Generating Board. The paper explains some of its design features. The facilities and services it affords are described in the companion paper (see previous column).

The methods employed in transmitting general indications and instructions over the rented Grid control networks, between Grid Control Centres and stations in the control areas, are explained, and the paper shows how group working is catered for by satellite and minor-station equipment and how unattended minor stations are controlled from associated major stations.

The design of the telephone system, which caters for administration as well as Grid control traffic, is explained in some detail, as also is the telemetering system with its initiating devices, miscellaneous instruments and arrangements for telemeter summation and retransmission. The paper concludes with a description of power supplies, testing facilities, alarms and general equipment.

To be read on the 28th May 1958

TECHNICAL PUBLICATIONS

BRITISH STANDARDS

Copies of the following publications can be obtained from the British Standards Institution, 2 Park Street, London, W.1. The prices given are post free.

B.S. 97: 1958 **Waterproof Electric Light Fittings** 4s. 6D.

This revised edition of B.S. 97 classifies waterproof fittings according to the type of enclosure and the degree of protection against the entry of water appropriate to the conditions of use. It applies to fittings enclosing either tungsten-filament or electric-discharge lamps operating at not more than 250 volts; it does not, however, apply to street-lighting fittings, which are dealt with in the separate Standard B.S. 1788, 'Street-Lighting Lanterns'.

The publication specifies general requirements and tests for electrical safety. There are also special tests for each of the five separate types of enclosure specified—watertight, submersible, hoseproof, splashproof and weatherproof.

The weatherproof, splashproof and hoseproof fittings are subjected to falling-water and splash tests of increasing severity. Hoseproof fittings, sometimes termed *jetproof*, are suitable for garages, etc., where jets of water under pressure may strike the fitting.

The watertight and submersible fittings are both suitable for use under water. The latter type is tested for suitability for permanent submersion to a depth of 10 ft.

B.S. 562: 1958 **Reversible Connectors for Portable Electrical Appliances** 5s.

A British Standard is now under consideration for a new type of non-reversible connector rated at 10 amp, in which the earthing contacts are not exposed, but the many existing appliances which now use the B.S. 562 reversible type of connector makes it necessary to retain this product as a standard type. It has therefore been decided to publish this revision of B.S. 562: 1934, in which a number of modifications have been made in order to provide a greater margin of safety.

The current rating of the connector has been increased from 7·5 amp to 10 amp at 250 volts, and it is required to be suitable for use on heat-generating appliances in which the temperature of the contact pins of the inlet socket does not exceed 150° C. Since the connector is not reversible, it is not suitable for use with appliances incorporating a single-pole switch.

The new publication specifies requirements for dimensions, materials and performance. Among the tests laid down are those for the effectiveness of current-carrying and earthing contacts, and there is a mechanical-shock test, to be made in conjunction with a heat-resistance test.

There are nine diagrams, among them being those for fully dimensioned gauges for the connector plug and inlet-socket and for a new design of inlet test plug to prove the

effectiveness of the inlet-socket earthing contacts. There are also detailed drawings for the test fixtures for measuring contact resistance and resistance to heat.

B.S. 646: 1958 Cartridge Fuse-Links (Rated at up to 5 amperes) for A.C. and D.C. Service 4s. 6d.

This revised publication relates only to the cartridge fuse-links included as Type A in the 1935 edition. Type B fuse-links are dealt with in B.S. 2950: 1958. Thus it deals with non-rewirable fuse-links with current ratings up to 5 amp, intended for use in plugs and socket-outlet adaptors to B.S. 646, for two-wire circuits with the declared voltages not exceeding 250 volts.

Current ratings of 1, 2, 3 and 5 amp are specified, according to the loading of the appliance for which the plug is required, and there is a colour code by which the current ratings are distinguished.

The Standard deals with voltage rating, current rating, fusing factor, breaking-capacity rating and performance. The section on tests specifies the use of both alternating and direct current for all tests for duty.

B.S. 2951: 1958 Glossary of Terms used in High Vacuum Technology 7s. 6d.

In any rapidly growing branch of technology there is need for guidance in the use of approved terms and their concepts. The purpose of this new British Standard glossary is to define the terms of accepted value in the many branches of science and industry where high vacuum technology has become important.

The glossary differs in detail from its 'opposite number' in the United States, but every endeavour has been made to ensure that as far as possible the same term is used with the same meaning in the two countries. Where a number of terms with approximately the same meaning have come into use, those preferred have been selected for definition. Certain terms which are redundant or deprecated have been listed separately in an appendix, together with the reasons for their rejection.

The glossary is arranged in sections, dealing separately with general terms, vacuum systems, pumps and pump components, manometers and gauges, leak detectors, and vacuum applications; the last-named section contains terms relating to well-known vacuum processes, including electrical and valve manufacture.

Comprehensive notes on pressure units, critical backing pressure and sensitivity definitions in leak detection are given in an appendix. The publication contains a list of the symbols and abbreviations used within its 26 pages; and ends with a detailed index to the terms defined or discussed.

BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION

The BEAMA Catalogue 1958 £6.

The fourth edition of 'The BEAMA Catalogue', which serves as a buyers' guide to the products and services of Britain's electrical manufacturing industry, has recently been published. The descriptive catalogue groups the products of member firms into three well-illustrated divisions: (*a*) electrical power plant; (*b*) electrical equipment in industry, transport and communication; and (*c*) domestic and commercial electrical appliances, lighting equipment, etc.

A five-language glossary of technical terms and separate indexes of products form a comprehensive cross-reference, particularly useful to the oversea buyer. A classified guide gives the names of manufacturers of electrical equipment under more than 1 300 headings, and the trade directory gives addresses of member firms and subsidiaries.

The catalogue is obtainable from the British Electrical and Allied Manufacturers' Association, 36 Kingsway, London, W.C.2.

BRUSSELS EXHIBITION

Serving the World. A souvenir booklet issued in connection with the electrical industry's exhibit in the British Industries Pavilion at the Brussels Universal and International Exhibition.

This booklet broadly surveys the British contribution to the development of electrical engineering. It is vividly produced in several colours and is designed to attract those who see it to visit both the British Industries Pavilion at the Brussels Exhibition and electrical engineering works in Britain herself. Some 25 000 copies have been distributed abroad, and about the same number are being given to interested visitors to the electrical industry's exhibit at Brussels.

A preface entitled 'For the good of all' outlines some of Britain's outstanding electrical achievements, past and present. It includes an appreciative reference to the work of The Institution. This preface is followed by more detailed sections on aspects of electrical engineering such as generation, transmission, traction, telecommunication, electronic engineering, television, lighting, etc. The booklet is well written and well illustrated throughout, and should readily appeal to the layman. Possibly the heavy end of the electrical industry gets a slightly bigger proportion of the available space than it should, but, rightly or wrongly, the emphasis of the exhibit at Brussels is also on supply and utilization. A limited number of copies of the booklet are available in Britain from the British Electrical and Allied Industry Section, Brussels Exhibition, 36 Kingsway, W.C.2, price 5s. plus 1s. postage.

ECONOMIC COMMISSION FOR EUROPE

Possibilities of Electric Power Exchanges between Countries of Central and South-Eastern Europe 3s. 6d.

The Economic Commission for Europe have recently published a report on the possibilities of exporting and importing electrical energy among the countries of Central and South-Eastern Europe. This discusses the energy resources of the countries concerned, their economies, their present consumption and production of electrical energy, their existing arrangements for transferring power and their future prospects for electrical generation. The report emphasizes that before nuclear power stations can be really useful in providing power for Europe, nations must co-operate over exports and imports of electrical energy. Some conclusions are drawn about suitable interconnecting systems among the Grids of the countries concerned and those of adjacent countries.

The report is available from Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2.

SOME RECENT BOOKS

TECHNICS AND PURPOSE

ALAN RICHARDSON: VOL. I—SCIENCE AND EXISTENCE. 30 PP.

EDWIN BARKER: VOL. II—SCIENTIFIC AND TECHNOLOGICAL EDUCATION. 37 PP.

H. A. WARREN: VOL. III—TECHNICAL EDUCATION: AN APPRAISAL. 37 PP.

MONICA WINGATE: VOL. IV—PURPOSE IN TEACHER TRAINING. 38 PP.

S.C.M. PRESS. 1957. 2S. 6D. EACH.

These four booklets are the first to be issued in a series sponsored by a working party convened by the Education Department of the British Council of Churches. They are important in showing how Christians are reacting to the challenge of science and of an expanding educational programme; and they are of particular potential importance to engineers, who are so largely responsible for creating the present need for more education. Professor Richardson's booklet, though beautifully written, is, however, rather abstruse; and while it is, no doubt, quite intelligible to the philosopher and theologian and will probably appeal to the pure scientist, it is not, in the reviewer's opinion, likely to prove valuable to most engineers.

The second booklet, by Mr. Barker, is of more direct interest. The author is Assistant General Secretary of the National Council of Y.M.C.A.s, and he finishes with an account of the way in which the Y.M.C.A. is prepared, partly through several suitable colleges of its own, to act as 'third partner' in the education of scientists and technologists, the other two partners being the universities and technical colleges on the one hand, and industry on the other. The main part of the book is rather verbose, but it does emphasize two important ideas. The first is that science and religion are each based on an act of faith, the former being based on a belief in rationality; thereafter both science and religion are subjective. The second is that education in science and technology should at first concentrate on mastery of science and technology, and only afterwards turn to the broader issues of life; it is argued that the students' interest in these will be aroused naturally. This is not a widely held view.

Mr. Warren's booklet gives, in the first half, a summary of the facts and organization of technical education, and although these will be familiar to many professional engineers the conciseness of the presentation makes the booklet valuable to those who want a quick general survey. The second half considers the social and cultural effects and problems of technical education. It discusses critically the themes that 'technics has already developed in a way which makes its meaningful integration with human life seem, at the present time, impossible', and that of 'fitness-for-purpose'; the latter leads into a discussion of 'ends and means', in which the Christian gospel appears as the only view of life providing realizable means and ends simultaneously. While the reviewer believes this himself, he does not find the author convincing. However, the author does himself admit that he is posing questions rather than answering them.

Monica Wingate's booklet is extraordinarily lucid and free from the abstruseness which spoils, to a greater or lesser extent, the first three in the series. Although few engineers are concerned with the training of teachers, yet almost all should find the booklet worth reading for its clear exposition of the purpose, not only of teacher-training, but of all education and, indeed, of life itself in a basically Christian, educated community.

J. JEWKES, D. SAWERS and R. STILLERMAN

THE SOURCES OF INVENTION

MACMILLAN. 1958. 428 PP. 31S. 6D.

A false god of the twentieth century may well prove to be the large organization. It has been dinned into people so much that group working is important that it has become almost an end in itself—small wonder then that many false ideas exist about industry and society and thus about the subject of the book reviewed here. Future historians of economic thought will doubtless find it remarkable that so little systematic attention was given in the first half of this century to the causes and consequences of industrial innovation.

Now, possibly not by any means too early, an urgent reassessment of the place of the individual is occurring. The book under review is based on a research project carried out in, and financed by, the University of Chicago and it exemplifies some of this present interest in the individual. It ably covers its subject and can be highly recommended. The book is divided into two parts. The first, which is stimulating and iconoclastic, discusses inventors and inventions in the last hundred years or so, the development of inventions, research in industrial corporations, and the individual inventor and some interesting conclusions and speculations. The second part gives summaries of case histories of sixty-one inventions, including the cyclotron, Diesel-electric railway traction, electric precipitation, fluorescent lighting, magnetic recording, radar, radio, and silicones.

Of the case histories, 'more than half can be ranked as individual inventions in the sense that much of the pioneer work was carried through by men who were working on their own behalf without the backing of research institutions and usually with limited resources. . . .' It is important to note that two-fifths of the patents issued in the United States and Great Britain are still issued to individuals, though this figure varies for different groups; for example, in some fields, notably chemistry and electronics, the dominance of the corporation is greater than elsewhere. The authors stress that large organizations cannot be considered, either actually or potentially, the sole source of inventions. Three facts point in this direction: such organizations have not been responsible in the past fifty years for the majority of the significant inventions, they continue to rely heavily upon other sources of original thinking, and they may themselves be centres of resistance to change. Painstaking efforts to 'avoid overlapping' frequently quench originality.

Interesting discussions on such subjects as the character and place of the inventor and the need for a multiplicity of types of research agencies will dispel many wrong concepts. A moral to be drawn from this book is that it is as important as ever to encourage individual effort and inventors.

The book is clearly printed in a size of type larger than is often found in comparable books to-day. It is well designed and produced, and is thus inviting to the eye, quite apart from the appeal of its content to the mind.

LIBRARY ACCESSIONS

** Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

ALLEN, M. J. 541.135

Organic Electrode Processes

London, Chapman and Hall, 1958. pp. xiv, 174. 23 × 15 cm. £1 12s.

The section of this book on the instrumentation and techniques of electrolysis will be of particular interest to members. The description of the basic phases of organic electro-chemistry concern the chemist.

ATABEKOV, G. E. 621.316.9

The Theory of Relay Protection of High Voltage Systems (In Russian)

Moscow, State Power Press, 1957. pp. 344. 26 × 17 cm.

BANNER, E. H. W. 621.317.7

Electronic Measuring Instruments. 2nd ed.*

London, Chapman and Hall, 1958. pp. xvi, 496. 23 × 15 cm. £2 16s.

Reviews first the general principles of electrical indicating instruments and then discusses the characteristics of hot- and cold-cathode valves, cathode-ray tubes, photocells, and metal and crystal rectifiers. The operating principles of instruments incorporating these devices are then described. The last part of the book deals with counters, recorders and gauges employing electromechanical transducers, thermistors and magnetic amplifiers. This is a considerable expansion of the original edition.

BIRR, K. 93: 53

Pioneering in Industrial Research. The Story of the General Electric Research Laboratory

Washington, Public Affairs Press, 1957. pp. vii, 204. £1 16s.

This is an account of the development of research laboratories in the General Electric Company, U.S.A., from the beginning of the century. It shows how important is fundamental research and invention, but does not describe projects in detail, remaining a picture for the administrator rather than the scientist.

BUCKLES, R. A. 347.77

Ideas, Inventions, and Patents. How to Develop and Protect Them

London, Chapman and Hall, 1957. pp. xv, 270. 23 × 15 cm. £2 8s.

This is a book for those who may wish to obtain a U.S. Patent.

BUCKLEY, R. W. 413 = 30

Essential German for Science Students*

London, University of London Press, 1954. pp. 256. 20 × 14 cm. 8s. 6d.

The primary aim of this book is to enable its user to translate intelligently from German. A survey of the essential grammar, with some exercises, is followed by progressively difficult passages for translation, each with its own vocabulary. A broad indication of the pronunciation is given.

CHURCH, A. H. 534.1

Mechanical Vibrations

London, Chapman and Hall, 1957. pp. xii, 275. 23 × 15 cm. £2 14s.

A rigorous treatment, using a mathematical and physical approach, of the basic principles of vibration analysis.

CONSIDINE, D. M. (Editor-in-Chief) 681.2

Process Instruments and Controls Handbook*

Prepared by a staff of Specialists
London, McGraw-Hill, 1957. pp. xxiii, 1286. 24 × 16 cm. £7 11s. 6d.

Deals with the operating principles and the design of instruments for the measurement of temperature, pressure, flow, liquid level, and chemical composition, and with equipment for automatic control.

CORK, J. M. 539

Radioactivity and Nuclear Physics. 3rd ed.*

London, Van Nostrand, 1957. pp. xii, 415. 22 × 15 cm. £2 18s. 6d.

This book will be of particular interest because of the descriptions of various types of counters and counting circuits, the impulse generators, the Van de Graaff generator, the cyclotron, Betatron, etc.

FLÜGGE, S. (Editor) 5

Handbuch der Physik Band V. Teil I. Prinzipien der Quantentheorie I. (Encyclopedia of Physics. Vol. V. Part I. Principles of Quantum Theory I)

Berlin, Springer, 1958. pp. 376. 25 × 17 cm. £6 3s. 1d.

The two chapters in this volume are in German. The first is entitled 'General Principles of Quantum Mechanics' and the second 'Quantum Electrodynamics'.

FLÜGGE, S. (Editor) 5

Handbuch der Physik Band XVI. Elektrische Felder und Wellen (Encyclopedia of Physics. Vol. XVI. Electric Fields and Waves)

Berlin, Springer, 1958. pp. vii, 753. 25 × 16 cm. £10 16s. 1

The chapters in this volume in the series are with one exception in English. They are on quasi-stationary and non-stationary currents, waveguides and resonators, and the propagation, dispersion and absorption of electromagnetic waves. The article in German is on static fields and stationary currents.

HALL, W. B. 621.03

Reactor Heat Transfer*

London, Temple Press, 1958. pp. viii, 68. 22 × 14 cm. 10s. 6

Volume III in the Nuclear Engineering series of monographs for university and technical college students. It deals with the important subject of convection heat transfer as applied to reactor design. The book will be reviewed in a future issue.

HAMANN, S. D. 539

Physico-Chemical Effects of Pressure

London, Butterworth, 1957. pp. ix, 246. 22 × 14 cm. £2 2s.

Discusses pressures in the range 10^3–10^5 atmospheres. Describes volumetric effects, changes of phase, and of solid form, dielectric and optical effects, electrolytic conduction under pressure, and equilibria in chemical reactions.

HARRIS, C. M. (Editor) 534

Handbook of Noise Control*

London, McGraw-Hill, 1957. pp. ix, 1033. 23 × 16 cm. £6

An exhaustive treatment of noise and vibration. The measurement and characteristics of noise of all kinds are discussed, including the legal aspect of the subject.

HUGHES, L. E. C. (General Editor) 621.38 (03)

Electronic Engineer's Reference Book

London, Heywood, 1958. pp. 1311. 19 × 12 cm. £4 4s.

This work is not intended to cover radar, radio and television, telecommunication, wave-filters and Service equipment. Its coverage includes electronic noise, isotopes, radiations, photocopying, r.f. heating, metals and non-metals, gauges, safety in industry, etc. Arranged in special classified order, it has also a detailed index. The book will be reviewed in a future issue.

JACKSON, S. P. 621.314.6

Selection and Applications of Metallic Rectifiers*

London, McGraw-Hill, 1957. pp. xiv, 326. 24 × 16 cm. £3.

This is intended to be a reference work on all types of metallic rectifiers. It covers their construction, characteristics and applications.

KINGSTON, R. H. (Editor) 621.315.59

Semiconductor Surface Physics

Philadelphia, University of Pennsylvania Press, 1957. pp. xvi, 413. 22 × 14 cm. £3 4s.

Papers and discussion of a conference held in June 1956. They deal with the latest interpretation of surface states, surface conductance, and related phenomena on germanium and silicon surfaces.

KLINKENBERG, A., and VAN DER MINNE, J. L. (Editors) 614.8

Electrostatics in the Petroleum Industry. The Prevention of Explosion Hazards*

London, Cleaver-Hume, 1958. pp. v, 191. 30 × 22 cm. £2.

This is a detailed description of research into the causes of static electricity, and methods for reducing the consequent danger in tanks. Prevention of the formation of explosive mixtures, earthing, and the use of anti-static additives are discussed.

LABOVITCH, C. (Editor) 37

The Directory of Opportunities for Qualified Men 1958*

London, Cornmarket Press, 1957. pp. 112. 22 × 14 cm. 8s. 6d.

Gives details of opportunities for qualified men and women in nearly a hundred industrial and commercial organizations and Government departments.

LEDGERWOOD, B. K. (Editor) 621–52

Control Engineering Manual. A Guide to the Practice of Control Systems Engineering, Including System Specification, Synthesis, and Evaluation; plus a Comprehensive Coverage of Design Techniques and Equipment Important to Automatic Control.

London, McGraw-Hill, 1957. pp. viii, 189. 29 × 22 cm.

£2 16s. 6d.

The book will be reviewed in a future issue.

McCORMICK, E. J. 621 : 744

Human Engineering*

London, McGraw-Hill, 1957. pp. xi, 467. 24 × 16 cm. £3.

This is a very detailed study of the human reaction to light, colour, visual displays, etc., to noise, and to temperature, humidity, altitude and motion. It discusses also the movements of the body relative to space requirements and the most convenient position of controls, etc.

McGHEE, H. A. 621.397.9

Industrial Television. Design and Application of Television Equipment in Industry, Education and Science

London, Newnes, 1957. pp. vii, 120. 19 × 13 cm. 15s.

Deals first with the practical aspects governing the choice of cameras and salient design considerations including associated control equipment. The requirements of specific applications of closed-circuit systems including underwater television, television microscopy, television telescopes and stereoscopic television are then described.

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 1st April 1958.

ELECTIONS

Associate Members

BUCKLEY, Frank Traquair, B.E.
CARAVAS, Spiro John, B.SC.(ENG.)
CHANTER, Norman James, M.SC., B.SC.
CONDON, Douglas Haig, B.E.
CULVER, John Oliver, B.SC.(ENG.)
COOPER, Thomas Leslie Brian, M.A.
DONNELD, Thomas
FORD, George Oscar Anstey
GARDINER, William
HEAT, Norman Thomas, B.SC.(ENG.)
HOLLOWAY, William Thomas, M.A.
HOPKINS, Gwilym John, M.A.
KIRKPATRICK, William Stanley
KOW, Tat Cheong, B.SC.(ENG.)
LADD, James Arthur, B.SC.
LOCKETT, George Edward
MORGAN, Idris Gareth, B.SC.
PARSONS, Alan Douglas, B.SC.(ENG.)
REW, Ronald
ROSE, David John, B.SC.(ENG.)
SPRY, Basil, B.SC.(ENG.)
TRACEY, Roland John
WAGER, Eric William
WALES, Edwin Charles

Associates

WOOLCOMBE, William Harry
SAWYER, Roland Henry
SENGUPTA, Hemendranath, B.SC.
SPELLER, Eric Richard

TRANSFERS

Associate Member to Member

ALLCOCK, Gerard Thomas, B.SC.
BARTON, Godfrey John, B.SC.
BROADBENT, Maurice Edward
CLARK, John, B.SC.
COW, Duncan Acheson, B.SC.(ENG.)
DAWTRY, James Ewart
DUTTON, Lt.-Col. Jesse, R.E.M.E.
FITZPATRICK, Hugh James, B.SC.
FOWLDS Ronald Humphrey
GOURIET, Geoffrey George
HASLEFOOT, Arthur John, M.A.
JEWELL, Edward Horace Tucker
KATER, Gregory Blaxland, M.A.
MARTINDALE, Robinson George, M.SC.
NEVITT, Henry John Barrington, B.A.SC., M.ENG.
NEWTON, Norman
ROBINSON, Thomas Frederic
SALVAGE, Bernard Frederick, B.SC.(ENG.), PH.D.
WILLIAMS, Commander Christopher Ryle, O.B.E., R.N.

Associate to Associate Member

ROTHWELL, Jack

Graduate to Associate Member

ATHERTON, Thomas Geoffrey Fenton, M.A.
AUSTEN, Reginald John
BALE, Bernard John
BARONI, Peter Robin
BENNETT, Brian Donald, B.SC.(ENG.)
BENSON, Desmond Patrick Joseph
BINNINGTON, Lt.-Comdr. Lawrence William, R.A.N.
BOLSER, Murray
BRAND, Hugh Roy
BRIARS, Colin Hubert
BROCKLEBANK, Richard Bennett
BRYAN, George Thomas
CROMBIE, Douglas Stewart
DAVIES, Thomas
DAVIS, Ronald
DRUMMOND, Robert Stewart
DUNN, William George Vercoe, B.SC.(ENG.)
EARNSHAW, James Donald, B.SC.(ENG.)
EBBEHØJ, Palle Ernst, B.SC.(ENG.)
GARNER, Alan John
GLAISHER, Edward James, B.SC.(ENG.)
GRANEAU, Peter, B.SC.(ENG.)
HAMILTON, Alexander, Jnr.
HOTZ, Basil Ralph, B.SC.(ENG.)
HUGHES, Arthur Harry
HUGHES, John Glanville
HURST, Stanley Leonard, B.SC.(ENG.)
JONES, Bryan Peter
JONES, Ronald William Hillier
KEEN, Geoffrey Hugh David
LEE, Edward Stewart Edmund
LYCETT, John Davis
LYON, Gerald William
MCGUIRE, Kenneth William
MARSDEN, Bernard
MARTIN, Basil Oliver
MERRY, Ian William, B.SC.(ENG.)
MIDGLEY, Jeffrey Henry
MILLS, David John
MORRIS, Thomas William Arthur, B.SC.(ENG.)
NAPPER, Leslie Frank, B.SC.(ENG.)
NOBLE, Samuel McCrudden, B.SC.(ENG.), M.SC.
NOCKOLDS, Frederick John, B.SC.(ENG.)
ORTTON, John Lee
PENNEY, Geoffrey William John
PRYCE, Robert David
RICHARDSON, Percy
SAYLE, Thomas George, B.SC.(ENG.)
SCHATZBERGER, Wolfgang Mark, B.SC.TECH.
SHAH, Raymond Ramon, B.SC.(ENG.)
SMITH, Herbert Francis
SOUNESS, James William, M.SC.
STEWART, James Bruce, B.SC.
STURGEON, Geoffrey William
TAYLOR, David Geoffrey, B.A.
WEST, Roger Frankland
WILKINSON, Kenneth Leonard
WILLIS, Bryan Erskine

Student to Associate Member

DAVIES, William Gwylfa, M.SC.

THE ENGINEERING INSTITUTIONS EXAMINATION (PART I) OCTOBER 1957

There are six Institutions participating in the Engineering Institutions Part I Examination:

THE INSTITUTION OF CIVIL ENGINEERS
THE INSTITUTION OF MECHANICAL ENGINEERS
THE INSTITUTION OF ELECTRICAL ENGINEERS
THE INSTITUTION OF MUNICIPAL ENGINEERS
THE INSTITUTE OF MARINE ENGINEERS
THE INSTITUTION OF GAS ENGINEERS

BRITISH ISLES

The following candidates have satisfied the examiners in the compulsory subjects of Part I (Mathematics, Applied Mechanics, Heat, Light and Sound, Principles of Electricity and Engineering Drawing):

AKINTOYE, Raphael Olaniyi[2]
ALLEN, Anthony David
AMARASURIYA, Amal Chandra[3]
BADR, Mohamed Kamal[2]
BADROCK, Geoffrey George[2]
BATEMAN, Ivor Henry[2]
BODDY, James Edward[3]
BRADLEY, Edward Maxwell
BRAYSHAW, Allan Roy[3]
BRETT, Thomas William
BULL, David John[2]
CAMPBELL, George[3]
CARVELL, Clifford Allen[2]
CHAUDHRY, Sushil Prakash
CLARKE, Michael Lane[2]
COLLINGWOOD, Raymond William
CROASDALE, Anthony James[2]
CUNNINGHAM, Richard Ross
DAY, Thomas Michael
DIXON, Raymond Ernest
DUFOUR, Peter Andrew Hyatt[2]
ELAND, John Border[2]
EVANS, Phillip George
EVERETT, William Jeremy
FOWLER, Alan John[2]
FRISTON, Anthony Harpham[2]
GAUTREY, Brian William[2]
GIDDENS, Roy[2]
GLENDINNING, Robert Arnold
GOULDING, John Malcolm
GOVINDARAJAH, Ratnasamy
GRIMSTON, Reginald[3]
HAXBY, Geoffrey
HEDGES, William Sydney Garth[3]
HIRSCHMAN, Gerald Michael Joseph[2]
HUMPHREYS, David Lewis
HUNT, Stephen[2]
HURL, Malcolm Rodney
HUTTON, Robert Walter John
HYETT, David Osborne[2]
IRELAND, John Michael
JONES, Vivian Edwin[2]
KHIN, Maung Chit
KING, John Audus
LAWLOR, Joseph Patrick
LEDWIDGE, Michael Denis[2]
LEE, Robert Malcolm[2]
LEFEVER, Geoffrey James[3]
LEGGE, Patrick John
LEVERINGTON, Peter John
LINGLEY, Peter James
LOWE, John Patrick[2]
MACFARLANE, Robert David[2]
MAJID, Mohd. Salleh Bin H. A.
MARGASON, Colin
MIKHAIL, Edward Abdel Sayed[1]
MILLER, Brian William[2]
MILLINGTON, Thomas Michael[2]
MOHAN, Gollakota Vijay
MOORE, Edward[2]
NARWARATNE, Premachandra Keerti Bandara
NEEDHAM, George David[2]
NOLAN, James Joseph
NUTTALL, Roy[2]
OLIVER, Ian Granville
OLLIS, John[2]
PALMER, Richard Marcus[2]
PATCHETT, Robert Glyn[2]
PEDERSEN, Aage
PHILLIPS, Barry Arthur
RAY, Asish Kumar
REYNOLDS, John Edward[2]
SCULLY, Cecil Raymond
SELLER, Brian
SELVARAJAH, Luther James
SHAH, Vipinchandra Laxmichand
SHEARER, James Barrie
SHEIDUN, Kolawole
SHELDON, William Gordon
SHERRIFF, Peter Alan
SPENCE, Michael[2]
SWIFT, Derek
TAMBE, Pratap Shripad[1]
THARMALINGAM, Sinnappu
TURNER, Kenneth[2]
VAISHYA, Krishna Chandra
VIAS, Augustine
WAH, Dennis Fong
WAKELING, Geoffrey James George[3]
WARD, Lindsay Hodkin
WEBBER, Edward Sutton
WILLIAMS, Stanley George[2]
WRIGHTSON, Barry Lyndon[2]

The following have satisfied the examiners in the subjects Mathematics, Applied Mechanics, Heat, Light and Sound, and Principles of Electricity of Part I:

FLETCHER, John[3]
JAYASEKERA, Aelian Alwis Cohomban Wickrama[3]
KENNARD, David Edward
KENNETT, William Clifford Aplin[3]
MACALISTER, Donald Duncan[3]
NEWSOME, George Keith[3]
SABON GARI, Adamu
SEIF, Obeid Abdulla[3]
WATERMAN, Robert Dennis
WHITCOMBE, Allen[3]

[1] *Also satisfied the examiners in the subject of English.* [2] *Also satisfied the examiners in the subjects Strength of Materials and Theory of Structures.*
[3] *Also satisfied the examiners in the subject of Theory of Structures.*

The following candidates have satisfied the examiners in the subject of English:

ALLEN, David Thomas James
APSEY, John Herbert
ASHWORTH, John Vernon
BOOTH, Albert Frederick
BOWEN, Gwynne
CATER, Herbert Richard
CHARLTON, Peter
CHATTERTON, Alan Nevill
CLEGG, Jack
CLEMO, Richard Philip David
COCHRANE, Cyril Frederick
COPPOCK, Alan Dennis
CROCKETT, John Alexander
DAVIES, William Edward
DUFFY, Gerald Ian
DYER, Maurice John
EDWARDS, Philip
FINCH, Norman Charles
GORSKI, Wojciech
HARROP, Neville John
JOHNSON, Alan Bernard
KING, Royston Charles
LINDON, Thomas Derek
LUCAS, Kenneth Graham
LUMLEY, William Neville
MALLEY, Roy Robert
MANSFIELD, Harold Edward
MASSIS, Zainudeen Mohammed
MORELAND, Brendan Roch
MORGAN, Ronald Arthur
O'DONNELL, Leonard William
OLDHAM, Samuel Roy
O'LEARY, Jeremiah
PACKER, John Brian
PAGE, Roger Francis Scott
RACIBORSKI, Jerzy
RAMSAY, Alastair Roderick
RAMSDALE, William
REECE, Percy Cairns
REID, Robert Henry Wanda
ROBERTS, William Henry
ROE, John David
SEDDON, Brian
SMITH, David Michael
SMITH, Thomas Gavin Gordon
SOUTHERN, William Gordon
STAYTON-DAVIS, Anthony Maurice
TRANTER, Peter George
TUBOKU-METZGER, Constant Ernest
TUSTIN, Raymond Cyril
WALL, Reginald James
WALLER, James Raymond
WARREN, Ronald James Alfred
WILLIAMS, George Richard

The following candidates have been permitted to enter the examination under special conditions and have satisfied the examiners in the subjects indicated:

BONNING-SNOOK, Michael John[1]
BRADY, John Francis[4]
BROWN, Paul Julian Douglas[5]
BROWN, Thomas James[4]
BROWN, Wallace Joseph[4]
BUTTERWORTH, Peter[1]
CAPELIN, Maurice Alec[1]
CARPENTER, Herbert James Thomas[5]
CARRIVICK, William Patrick[4]
COOPER, Geoffrey[1]
COPEMAN, Edward Charles Thomas[1]
COWELL, Peter Alfred[5]
EASTMAN, Charles John[1]
EGAN, Matthew[2 5]
ETHERINGTON, Roger Frank[3 4]
FENNE, Ivor[3 4]
HANCOCK, Raymond Michael[3 4 5]
HART, Dennis Claude[1 3 4]
HURLEY, Norman John[1]
IRWIN, Quinton Frederick[2 3 4]
JACKSON, Terence Charles[5]
JEFFERSON, Bryan Arthur[5]
KATHJU, Naresh[4 5]
KRISHNASAMY, Kanapathipillai[5]
LIVING, David Edwin[4]
MCCALL, Henry, Junr.[4]
MCKEOWN, James[2 3 4 5]
MCLACHLAN, Edward Duncan[4]
MACLEOD, Hector Malcolm[1]
MEEKE, Charles Harvey[4]
MILES, Derek[2 4 5]
MISCHEL, Alexander[3 4 5]
MITCHINSON, George Edward[4]
MOORE, Joshua William[1]
MORTIMER, Sydney[3 4]
O'GALLAGHER, Patrick Francis[2]
PETRIE, Robert Conway[1]
PICKLES, John Robert[4]

THE INSTITUTION EXAMINATION — List of Successful Candidates (*cont.*)

PITT, Kenneth David[1]
PLASTOW, Gerald Lloyd[1]
QUINNEN, Ronald[2 3 5]
REES, David Colin[1]
SAUL, Solomon[2 3 5]
SAVIN, John Bruce[4]
SEDDON, Alan Terence[4]
SHAW, John[1]
SLADE, Donald Charles[1]
SONI, Satya Pal[5]
SOOSAIPILLAI, Anton Manoretnam[4 5]
STERN, Herman Peter[2 5]
STEVENS, Rex[1]
STRUNC, Miloslav[3]
THOMAS, Dennis[1]
TONG, Andrew Hsueh-Cheng[5]
TRIPP, Alfred Rixhard[4]
TURTON, Colin Graham[4]
VARLEY, John Richard[2 3 5]
VERNEM, Charles Douglas[2 3 5]
WEBB, John Brian[1]
WEST, Samuel John[4]
WILLS, Keith Ernest[3 4 5]

[1] *Mathematics.* [2] *Applied Mechanics.* [3] *Heat, Light and Sound.* [4] *Principles of Electricity.* [5] *Engineering Drawing.*

OVERSEA

The following have satisfied the examiners in the compulsory subjects of Part I (Mathematics, Applied Mechanics, Heat, Light and Sound, Principles of Electricity and Engineering Drawing):

CLAYTON, Colin Duke
FICK, Benjamin Alexander
FRENCH, Terence[3]
HUNT, Steven Alton[2]
JARVIS, Neville John David
LEMMON, Anthony William
LINDESAY, Denis Alan
LOSA, Emmanuel Efue
MITCHINSON, William George[2]
OKIN, Stephen Omoniyi
PATEL, Prabhudas Somabhai[2]
PIRIE, Kenneth Charles[1]
POPE, Richard David[2]
REYNOLDS, William Herbert
RILEY, John Kenneth
SKEA, David Mackenzie
SOMERS, Desmond James

The following have satisfied the examiners in the subjects Mathematics, Applied Mechanics, Heat, Light and Sound, and Principles of Electricity of Part I:

ABBOTT, John Rupert[3]
EUYEN, Eduard Johan Anton[2]
O'BRIEN, Noel William[2]
VALENTINE, James Alexander[3]
VAUGHAN, Barry Evan Jones[3]
WHITE, Bruce Rodney[3]

[1] *Also satisfied the examiners in the subject of English.* [2] *Also satisfied the examiners in the subjects Strength of Materials and Theory of Structures.*
[3] *Also satisfied the examiners in the subject Theory of Structures.*

The following candidates have satisfied the examiners in the subject of English:

BEHR, Bjorn Einar
COLLIS, Milne Walter
GANNON, Thomas Derek
HODGE, William Crawford
KNIGHT, Kenneth John Gerald
MCGARRICK, Ian Milton Bennett
MORRISON, David Laird
PATCHETT, John Rollo
PATTERSON, Carl Wight
SINCLAIR, Derek Gordon
TYSON, Donald William
WOOD, William Barrington

The following candidates have been permitted to enter the examination under special conditions and have satisfied the examiners in the subjects indicated:

ALLAN, George Neville[2 3]
ANDREAS, Cyril Kenneth[5]
BEHR, Bjorn Einar[1 2 4]
COPPING, John Kay[4]
CROSBIE, Ivan Francis[1 2]
DUNKLEY, Godfrey Robert Armantage[2 3 5]
GANNON, Thomas Derek[4]
HAMPSON, William Rowland[3]
HODGE, William Crawford[4]
KNOWLES, Keith Francis Joseph[5]
MARCHANT, Laurence William[1 2]

[1] *Mathematics.* [2] *Applied Mechanics.* [3] *Heat, Light and Sound.* [4] *Principles of Electricity.* [5] *Engineering Drawing.*

THE INSTITUTION EXAMINATION (PARTS II AND III) OCTOBER 1957

PART II

BRITISH ISLES

BLACKWOOD, William
CORREIA, John Basil
DE COURCEY BOWER, John Bingham[2]
DEMPSEY, Thomas Anthony
EDIRISINGHE, Don Francis
FITZPATRICK, Christopher Martin
GALLACHER, Joseph[2]
GOULDING, Royston David[1]
HABENS, Bernard[1 3]
HEATHERLEY, Joseph Charles
JOHNSON, Dennis[4]
LEWIS, Vernon John[1]
MANN, Michael George[1]
MITCHELL, Terence[1]
MORAGHAN, James Sylvester
ROY, Rathindra Nath
SAMBASIVAM, Thiagarajah
SHEIKH, Ghulam Muheyyuddin
THOMAS, Gwyn[1]

OVERSEA

BENSON, Collin Clive[1]
CAHILL, Patrick Joseph[1]
DICKSON, Richard James
DUNFORD, Graeme Wilmor[1]
GRANGER, Murray James
HOLLAND, Alan Dennis[1]
MEYER, Robert James
MORGAN, Howard James Moncur
RABY, Ronald Ernest[1]
ROMIJN, Maarten
SAUNDERS, Leith Roy[1]
SULLIVAN, James Warwick[3 8]
SWIFT, Graham George
TEN KLEY, Willem Berend[1 4]
VELTMAN, Frederik
WILSON, Albert Keith

PART III

BRITISH ISLES

BARON, Peter[5]
CLYANIS, Elpidoforos Nicholas[5]
DACHENHOLD, Wolfgang Friedrich[5]
DANCROFT, George[5]
DRADLEY, David[5]
DAVIES, Charles Aneurin[5]
DEAN, Kenneth John[5]
FINLEY-MAXWELL, David Campbell[5]
HAMMERSLEY, David Anthony[5]
HARVEY, Peter John[6]
ORMSBY, Hedley[5]
REYNOLDS, John Spackman[5]
ROY, Rathindra Nath[7]
SHARPE, Frank[5]
SMYTH, Nicholas David[6]
TONG, Jonathan Felix[5 6]
WELSH, Alexander Wright[5]
WIGGANS, Michael Thurston Richard[5]
WRIGHT, Michael John[6]
ZAKI, Mohamad

OVERSEA

BAILEY, William Dalziel
BAILLIE, Theodore Henry[6]
BAWTHRAW, Maurice John[5]
EDDY, David Charles Ancell[5]
GIVEN, Charles Douglas Harper
HOOPER, Thomas Leslie[5]
LEE, Thomas Joe[5 6]
LEVY, Israel
MCCALMAN, Laurence Chanel[6]
PARNELL, James Crawford
SMITH, Colin Morice

[1] *Electrical Engineering I and II only.* [2] *Electrical Engineering I only.* [3] *Engineering Physics only.* [4] *Thermodynamics only.* [5] *Advanced Electrical Engineering only.*
[6] *One Special Subject only.* [7] *Two Special Subjects only.* [8] *Mathematics only.*

Forthcoming Events at Savoy Place

All meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

M MEASUREMENT AND CONTROL SECTION
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper is added the page on which a synopsis appears in the *Journal* under 'Monographs and Papers published individually this month'.

A paper that has not yet been published will be available at least ten days before the meeting at which it will be read.

May 1958

U **16–18** *Friday–Sunday* Section Visit to Porthcawl

R **19–23** *Monday–Friday* International Convention on Microwave Valves (Full details and registration form obtainable from the Secretary)

S **28** *Wednesday* P. F. GUNNING 'Standardization of Control Facilities for the British Grid Communications, Indications and Telemetering' (Paper No. 2626 s) *Synopsis:* see p. 271

G. A. BURNS, F. FLETCHER, C. H. CHAMBERS *and* P. F. GUNNING 'The Development of Communication, Indication and Telemetering Equipment for the British Grid' (Paper No. 2627 s) *Synopsis:* see p. 271

S **31** *Saturday* Section Visit to Leatherhead

June

M **7** *Saturday* Section Visit to B.B.C. Television Studios and Electricity Council Training Establishment

25 *Wednesday* Institution Conversazione at the Royal Festival Hall, at 7.30 p.m.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review or special article. Where given, the date in capitals refers to the month in which a paper was published individually.

PART A. POWER ENGINEERING (APRIL 1958)

See the Journal for April 1958, p. 215.

PART B. RADIO AND ELECTRONIC ENGINEERING (MAY 1958)

P. L. CLOOT, M.SC.(ENG.). PAPER NO. 2585 M

A Basic Transistor Circuit for the Construction of Digital-Computing Systems *May 1958*

F. J. HYDE, M.SC., AND R. W. SMITH, B.SC. PAPER NO. 2548 R

An Investigation of the Current Gain of Transistors at Frequencies up to 105 Mc/s *April 1958*

Sub-Centre Chairmen's Addresses

G. B. B. CHAPLIN, M.SC., PH.D., AND R. WILLIAMSON. PAPER NO. 2440 M, NOVEMBER 1957

Dekatrons and Electro-Mechanical Registers Operated by Transistors *January 1958*

G. M. ETTINGER, B.SC.(ENG.), M.SC.(ENG.). PAPER NO. 2353 M, APRIL 1957

Some Aspects of Half-Wave Magnetic Amplifiers *February 1958*

G. B. B. CHAPLIN, M.SC., PH.D., AND A. R. OWENS, M.SC. PAPER NO. 2382 M, JULY 1957

Some Transistor Input Stages for High-Gain D.C. Amplifiers *February 1958*

G. B. B. CHAPLIN, M.SC., PH.D., AND A. R. OWENS, M.SC. PAPER NO. 2442 M, NOVEMBER 1957

A Transistor High-Gain Chopper-Type D.C. Amplifier *February 1958*

Written discussion on **The Remote and Automatic Control of Semi-Attended Broadcasting Transmitters** and **The Design of High- and Lower-Power Medium-Frequency Broadcasting Transmitters for Automatic and Semi-Attended Operation**

W. H. ALDOUS, B.SC. PAPER NO. 2560

Thermionic and Cold-Cathode Valves (*Review of Progress*) *May 1958*

R. G. MEDHURST, B.SC., MRS. E. M. HICKS, B.SC., AND W. GROSSETT, PAPER NO. 2565 R

Distortion in Frequency-Division-Multiplex F.M. Systems due to an Interfering Carrier *May 1958*

J. HARWOOD, M.A., PH.D. PAPER NO. 2619 R

Atmospheric Radio Noise at Frequencies between 10 kc/s and 30 kc/s *May 1958*

D. D. CROMBIE, M.SC., A. H. ALLAN, B.E., AND MISS M. NEWMAN, B.SC. PAPER NO. 2562 R

Phase Variations of 16 kc/s Transmissions from Rugby as Received in New Zealand *May 1958.*

PART C. MONOGRAPHS (MARCH 1958)

See the Journal for March 1958, p. 158.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH APRIL 1958

£1 000 and over	6	6 000	0	0
£100 to <£1 000	30	6 586	3	0
£5 to <£100	855	9 070	6	7
£2 to <£5	2 075	5 684	11	11
Under £2	23 927	12 427	14	9
		£39 768	16	3

APPOINTMENTS AND NOMINATIONS

COMMITTEE ON RADIO INTERFERENCE

On the nomination of the Admiralty, the Council have appointed Lt. J. N. Wishart, R.N., to serve on the above Committee in place of Lt. D. R. Leighton, R.N.

COMMITTEE ON REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF SHIPS

On the nomination of the Ministry of Transport and Civil Aviation, the Council have appointed Mr. G. Burdon, B.SC., to serve on the above Committee in place of Mr. F. J. Welch, C.B.E.

WIRING REGULATIONS COMMITTEE

On the nomination of the Fire Offices Committee, the Council have appointed Mr. W. R. Whittington to serve on the above Committee in place of Mr. T. H. Adie, alternate to Mr. C. E. Mills.

SCIENCE ADVISORY COMMITTEE OF THE BRITISH COUNCIL

The Council have nominated Sir Harold Bishop, C.B.E., B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee in place of Mr. T. G. N. Haldane, M.A., MEMBER.

COMMITTEE ON RADIO INTERFERENCE

On the nomination of the Ministry of Transport and Civil Aviation, the Council have appointed Mr. J. T. Penwarden to serve on the above Committee in place of Mr. W. L. Shaw.

B.S.I. TECHNICAL COMMITTEE NO. 13—MEASURING INSTRUMENTS

The Council have nominated Dr. G. F. Tagg, B.SC.(ENG.), MEMBER, to serve on the above Committee.

B.S.I. SUB-COMMITTEE ELE/3/20—POLYTHENE INSULATION AND SHEATH

The Council have nominated Mr. C. E. Mills, MEMBER, to serve as their representative on the above Sub-Committee.

B.S.I. SUB-COMMITTEE ELE/3/21—HEAT-RESISTING CABLES

The Council have nominated Mr. C. E. Mills, MEMBER, to serve on the above new Sub-Committee for liaison with the Wiring Regulations Committee.

B.S.I. SUB-COMMITTEE ELE/10/23—MINIATURE CIRCUIT-BREAKERS

The Council have nominated Mr. J. S. McCulloch, ASSOCIATE, to serve as their representative on the above Sub-Committee.

PROPOSED NATIONAL APPROVALS AND MARKING SCHEME FOR DOMESTIC ELECTRICAL EQUIPMENT

The Council have nominated Mr. Forbes Jackson, MEMBER, to serve as their representative on the Provisional Committee in place of the Secretary.

INDUSTRIAL FUEL EFFICIENCY EXHIBITION—ORGANIZING COMMITTEE

The Council have nominated Mr. H. V. Pugh, MEMBER, to serve as their representative on the above Committee.

INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE—BRITISH SECTION

The Council have nominated Mr. B. Donkin, B.A., MEMBER, to serve on the above Commission in place of Mr. G. R. Peterson, B.A., MEMBER.

BRITISH ELECTRICAL POWER CONVENTION

The Council have nominated Mr. B. L. Metcalf, B.SC.(ENG.), MEMBER, to serve on the Council of the B.E.P.C. for the year 1958–59.

NATIONAL ADVISORY COUNCIL OF THE ELECTRICAL ASSOCIATION FOR WOMEN

The Council have nominated Dr. P. Dunsheath, C.B.E., M.A., MEMBER, to serve on this Council in succession to Sir Arthur Fleming, C.B.E., D.ENG., LL.D., HONORARY MEMBER.

TAUNTON TECHNICAL COLLEGE ADVISORY COMMITTEE FOR ENGINEERING AND SCIENCE

The Council have nominated Mr. D. George, ASSOCIATE MEMBER, to serve on the above Committee.

CHANGE OF EDITOR

Mr. C. T. Rivington, who has edited the *Journal* from 1955, when it first appeared in its new form, until last month, has now relinquished the editorship. His place is shortly being taken by Mr. W. G. Askew, who joins the Institution staff from an industrial appointment.

LOCAL CENTRE AND SUB-CENTRE AREAS

The Council have recently authorized the following alterations to Centre and Sub-Centre boundaries:

(1) *North Midland and East Midland Centres* The area of Lincolnshire not at present attached to any Centre has been divided between the North Midland and East Midland Centres, the dividing line to run from a point south of Gainsborough on the border of the present Sheffield Sub-Centre to the coast immediately north of Mablethorpe. The area north of this line is to be allocated to the North Midland Centre, meeting facilities being provided by the Sheffield

Sub-Centre. The area south of this line will become the responsibility of the East Midland Centre.

(2) *Mersey and North Wales Centre* The Isle of Man is to be allocated to the Mersey and North Wales Centre.

Oswestry and district together with Whitchurch and district is to be transferred from the South Midland Centre to the Mersey and North Wales Centre.

(3) *North Lancashire Sub-Centre* The area of Westmorland not at present attached to any Centre or Sub-Centre is to be allocated to the North Lancashire Sub-Centre.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

Members who may have to travel abroad are reminded that in certain countries reciprocal arrangements are in operation for the extension of privileges to visiting members. The complete list of Institutions concerned is now as follows:

Country	*Institution*
Australia	Institution of Engineers, Australia.
Austria	Österreichischer Ingenieur- und Architekten-Verein.
Belgium	Société Royale Belge des Ingénieurs et des Industriels.
	Société Belge des Électriciens.
Brazil	Instituto de Engenharia, São Paulo.
Canada	Engineering Institute of Canada.
Denmark	Dansk Ingeniørforening.
Finland	Suomen Teknillen, Seura.
	Tekniska Föreningen i Finland.
France	Société des Ingénieurs Civils de France.
	Société Française des Électriciens.
Germany	Verein Deutscher Ingenieure.
	Verband Deutscher Elektrotechniker.
Holland	Koninklijk Instituut van Ingenieurs.
Iceland	Association of Chartered Engineers in Iceland.
India	Institution of Engineers, India.
Italy	Associazione Elettrotecnica Italiana.
Japan	Institute of Electrical Engineers of Japan.
New Zealand	New Zealand Institution of Engineers.
Norway	Norsk Elektroteknisk Forening.
	Norsk Ingeniørforening.
Rhodesia	Rhodesian Institution of Engineers.
South Africa	South African Institution of Civil Engineers.
	South African Institute of Electrical Engineers.
	South African Institution of Mechanical Engineers.
Sweden	Svenska Teknologföreningen.
Switzerland	Schweizerischer Ingenieur- und Architekten-Verein.
Turkey	Turkish Engineering Society.
United States	American Institute of Electrical Engineers.
	American Institute of Chemical Engineers.
	American Institute of Mining and Metallurgical Engineers.
	American Society of Civil Engineers.
	American Society of Mechanical Engineers.
	Institute of Radio Engineers.

The Secretary will gladly give letters of introduction to members visiting these countries.

INTERNATIONAL SYMPOSIUM ON NUCLEAR ELECTRONICS

PARIS: SEPTEMBER 1958

An International Symposium on Nuclear Electronics organized by the Société des Radioélectriciens will be held from the 16th to 20th September 1958, at Unesco House, 2 Place de Fontenoy, Paris. The Symposium is sponsored by the Commissariat à l'Énergie Atomique and the International Union for Pure and Applied Physics, and its purpose is to examine and discuss the results obtained recently in the various applications of electronics to all aspects of atomic energy. Altogether ten sessions, each of half a day's duration, will be held. These will be devoted to: radiation and particle detectors; pulse techniques; reactor control; health and radioactive survey instrumentation; data processing; transistorization; and equipment and components standardization. Members of The Institution are welcome, and those wishing to attend the Symposium are required to register in advance; a fee is payable. Further particulars can be obtained from Colloque International 'Électronique Nucléaire', 10 avenue Pierre-Larousse, Malakoff (Seine), France.

HARWELL ISOTOPE SCHOOL

The Harwell Isotope School is arranging a course on radio-isotopes which is designed for senior industrial executives and will take place from the 23rd to 26th September 1958. The emphasis in the course will be on the application of radioisotopes in industry and research, and the lectures will be in simple language. There will also be visits to a reactor, to the isotope laboratories at Harwell and the Wantage Radiation Laboratory.

Those attending the conference will stay in an Oxford college, and transport to Harwell and back each day will be arranged. The fee for the course, including board and lodging and transport, is £40. Details and application forms may be obtained from The Registrar, Isotope School, Atomic Energy Research Establishment, Harwell.

PROCEEDINGS OF THE THIRD EUSEC CONFERENCE ON ENGINEERING EDUCATION

The Proceedings of the Third Conference of the Engineering Societies of Western Europe and the United States of America (Eusec) on Engineering Education, held in Paris in September 1957, have now been printed. They are available, on application to the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1, at the following prices:

Members of Participating Societies (including members of The Institution)	£1 5s.
Non-Members	£1 10s.

The volume of Proceedings contains the full reports, the general reporters' introductory remarks and a summary of the discussion on the following subjects:

1. Education glossary and block and flow diagrams.
2. General education before admission to engineering schools of university level.
3. Education at engineering schools of university level.
4. Practical training.
5. Post first-degree education.
6. Criteria for professional recognition.

In addition, three countries—the United Kingdom, the United States and Belgium—have each published a separate appendix, setting out more fully their own contribution to the Conference. For example, the British contribution contains, *inter alia*, complete replies to the questionnaires on the six subjects mentioned above, together with detailed syllabuses and examination papers. The three appendixes are obtainable as follows:

British Contribution to the Conference Price 15s. (non-members, £1) Obtainable from the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

United States Contribution to the Conference Price 3.50 dollars Obtainable from the Secretary, Engineers' Council for Professional Development, Room 1401, 29 West 39th Street, New York 18, N.Y., U.S.A.

Belgian Contribution to the Conference Price 30 Belgian francs Obtainable from the General Secretary, Société Royale Belge des Ingénieurs et des Industriels, 3 rue Ravenstein, Bruxelles, Belgique.

A report of the Conference will be published in the *Journal*

POST-GRADUATE COURSE IN NUCLEAR POWER

A second one-year full-time post-graduate course in nuclear power has been arranged for the session 1958–59 by the Imperial College of Science and Technology. It is intended for students holding a good honours degree in engineering, physics or metallurgy. The arrangements for the course have been based on the belief that nuclear power is not a distinct technology, but a new field of application for the existing basic branches of engineering and applied science. Leading figures in both the Atomic Energy Authority and the engineering industry have been consulted in planning this course, which reflects the policy of the British Nuclear Energy Conference, by covering the interests of engineers and applied scientists working in the atomic energy field. A special feature of the course is the inclusion of a design study of a complete nuclear power station or related process engineering project, and each student is given a particular part of the design related to his interests and background to carry out in detail during the year.

The syllabus of the course is divided into Backbone Lecture Courses, Optional Lecture Courses and Drawing Office Laboratory Work; visits will be arranged to establishments of the Atomic Energy Authority, etc. The course will be under the direction of Professor J. M. Kay, assisted by the staff of the college.

The fee for the course will be £64 (subject to revision), and applications for admission should be made by the 1st July 1958 on a form obtainable from the Registrar, Imperial College, London, S.W.7.

INSTRUMENTATION AND COMPUTATION IN PROCESS DEVELOPMENT AND PLANT DESIGN

A B.C.A.C. SYMPOSIUM IN 1959

The Institution of Chemical Engineers, the Society of Instrument Technology and the British Computer Society are organizing, under the aegis of the British Conference on Automation and Computation, a symposium on Instrumentation and Computation in Process Development and Plant Design, which will be held in the Central Hall, Westminster, from the 11th to 13th May **1959.** There will be five sessions on such subject-matter as the design of new processes, the application of on-line computers, and recent developments in instruments and computers. Anyone wishing to present a paper at this symposium should send a summary by the 1st June 1958 to the General Secretary, The Institution of Chemical Engineers, 16 Belgrave Square, London, S.W.1.

AUTOMATIC COMPUTING: SUMMER SCHOOL

A summer school in programme design for automatic digital computing machines will be held in the University Mathematical Laboratory at Cambridge from the 15th to 26th September 1958. The course has been revised and will give basic training in the mathematical uses of machines; it will deal with the processes employed and their embodiment in programmes which specify the operation. Students will have access to the new fast computer EDSAC 2. A detailed syllabus and an application form may be obtained from Mr. G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge, to whom the completed application form should be returned not later than the 16th June 1958.

AN ESSAY COMPETITION

The publishers of *Research* invite entries for their 1958 Waverley Gold Medal Essay Competition. The gold medal and £100 will be awarded for the best essay of about 3000 words based on some recent scientific research or new development, not necessarily carried out by the competitor, and giving some indication of its scientific background, the experimental results and its potential application in industry. The essay should be written so that it is clearly intelligible to a scientist engaged in another field or a director of an industrial firm. The essays will be judged for technical content, clarity of presentation and style. A second prize of £50 will also be awarded, with an additional prize of £50 for competitors under the age of thirty.

The closing date for the competition is the 31st July 1958. Full details will be supplied on application to *Research*, 4–5 Bell Yard, London, W.C.2.

THE BENEVOLENT FUND

The Court of Governors are pleased to acknowledge a contribution of £2 to the Benevolent Fund, sent by an anonymous donor.

ENCLOSURES WITH THE *JOURNAL*

Members are asked to note that, commencing with the June issue, the separate circulars, notices, etc., which are customarily enclosed with the *Journal* will be found in future *inside the front cover* instead of being placed on the top of the front cover. The change permits wrapping by machine instead of by hand, with some saving of time between printing and posting.

NUCLEAR REACTOR TECHNOLOGY

BRADFORD INSTITUTE OF TECHNOLOGY: 2ND JUNE–11TH JULY 1958

A six-weeks' full-time course on nuclear reactor technology will be held at the Bradford Institute of Technology from the 2nd June to 11th July 1958. Although no previous knowledge of the subject will be assumed, the course is designed for graduates or for those having graduate membership of a professional institution. There will be about eighty lectures and seventy hours of laboratory work, supplemented by discussion and study periods and by visits and film programmes. The fee for the course is £30.

Further details and application forms may be obtained from The Principal, Bradford Institute of Technology, Bradford, 7.

AIR TRANSPORTATION CONFERENCE

BUFFALO, NEW YORK: 25TH–27TH JUNE 1958

The Air Transportation Committee of the American Institute of Electrical Engineers have organized an Air Transportation Conference to be held at the Statler Hotel, Buffalo, New York, from the 25th to 27th June 1958. Over seventy papers will be presented by engineers in the aircraft industry and the Armed Forces of the United States and Canada. The papers are primarily concerned with high temperature, reliability, missile equipment, electrical ground support, instrumentation and radiation effects.

The programme and further information may be obtained from Mr. S. H. Hanville, Chairman, Arrangements Committee, Jack and Heintz Inc., Cleveland, 1, Ohio.

LONDON REPORT

DISTRICT MEETING AT OXFORD

The final District Meeting of the session was held at the Oxford Offices of the Southern Electricity Board on the 12th March, when Mr. F. J. Lane presented a paper on *High-Voltage D.C. Transmission.*

Special reference was made to the cross-channel cable, and the economic origins of the project were described. The speaker continued with a survey of all the problems involved and described the comprehensive sea trials which were carried out for the 132 kV 100 MW a.c. link.

Swedish experience in high-voltage d.c. transmission and various other factors had led to a re-examination of the scheme, and Mr. Lane detailed the points which led to a final decision to employ a 160 MW cable operating at ±100 kV d.c.

Mr. J. L. Taylor, the convenor, presided over the meeting, and Mr. A. Andrews complimented Mr. Lane on an extremely interesting and well-presented paper. L. W. F.

THE FARADAY LECTURE

The Why and How of Electrified Railways

As most members will know, this year's Faraday Lecture on railway electrification has been clouded by the death of the lecturer, Mr. G. H. Fletcher. He was a member who had been engaged during the whole of his working life on electric traction, and the Council turned rather naturally to him when the subject for the Lecture was fixed. Although no longer a young man, Mr. Fletcher readily agreed to take on this by no means light assignment, and, typically, threw himself heart and soul into the preparations. Before he died he had given the Lecture in Newcastle, Sheffield and Birmingham. In addition, he was to have repeated the Lecture in Rugby, Cardiff, Southampton, London, Hanley, Nottingham, Manchester, Liverpool and Glasgow; the halls had been booked and in some towns the tickets had been issued. But luckily, in Mr. R. Ledger, Mr. Fletcher had a most able deputy, who very kindly agreed to deliver the remaining Lectures in his stead. The task which thus fell to him was a heavy one and the Council wish to take this opportunity of recording their deep appreciation of Mr. Ledger's invaluable help. Like the late Mr. Fletcher, he is a specialist in electric traction, and as those who have been fortunate enough to be present at one of his Lectures know, he is able to deal most successfully with the job he has inherited.

1 *Mr. Ledger demonstrates the control gear for a d.c. traction motor driving the axle on the left of the photograph*

2 *On the rostrum in the Central Hall, Westminster, Mr. Ledger explains the equipment to be found in an electric locomotive with the aid of a demountable scale model*

In the background is a painting showing a Grid line and substation along the side of an electrified railway.

London's turn for the Lecture came on the 12th February 1958, and on that evening an audience of some 2 000 gathered at the Central Hall, Westminster, to hear Mr. Ledger and to see the many ingenious demonstrations which helped to give added life to a subject of perennial attraction—particularly to schoolboys. We must record, too, that the President, Mr. T. E. Goldup, delighted the audience with a recital of organ music during the half-hour between the doors opening and the start of the Lecture. Future Presidents please note!

In his Lecture Mr. Ledger dealt with the proposals put forward by the British Transport Commission for railway electrification in this country, and he drew attention to a number of technical advances, particularly in rectification and insulation, which have made a.c. electrification at 25 kV a practical possibility. Dealing with the economics of the subject, Mr. Ledger pointed out that at a voltage of 25 kV twelve substations could do the work of the seventy required for a supply at 1 500 volts d.c.

A demonstration convincingly brought home the saving in coal which would be effected by the wide-scale electrification of the railways. Mr. Ledger showed that of each 100 lb

coal used for steam traction, only the energy from 9 lb is available to haul the train, the rest being lost through incomplete combustion, exhaust losses, radiation losses, etc. A very different story appears when the coal is consumed in a power station, for then the energy from 26½ lb out of every 100 lb of coal becomes available for traction purposes. Moreover a much inferior coal may be burned in power stations, so that, apart from the total saving of about 107 tons of coal to be gained by electrification, there is also the release for export of large quantities of high-grade coal. In all, running costs can be reduced by about 50% and the number of locomotives by about one-third. Traffic can be speeded up, particularly where gradients are difficult for steam traction; a film of the Manchester–Sheffield line, which is notoriously difficult for steam traction, showed that during a 24-hour period an electric locomotive could work goods traffic over 288 miles, as against the 100 miles covered by a steam locomotive; this results in the saving of 105 train crews, equivalent to 315 men.

A particularly ingenious one-eighth-scale model locomotive with 'removable insides' was used to show the difference between the machinery compartments of a d.c., an a.c., and a Diesel-electric locomotive. With the aid of his assistants, Mr. Ledger also demonstrated the dead man's handle and—of great interest to the many schoolboys present—how to drive an electric train. He touched upon another application of electricity to railways—signalling; with the aid of the model locomotive, a controller and other equipment, he demonstrated the system of automatic train control which has been adopted by British Railways. With thoughts of two recent train disasters in mind, one felt that the audience accepted rather quizzically Mr. Ledger's explanation that final responsibility for stopping the train still rested with the driver, who had power to cancel the warning given him of a signal at danger.

The applause which met the President's vote of thanks at the end of the Lecture emphasized that Mr. Ledger had provided a most entertaining Lecture. In his reply, Mr. Ledger referred to the team-work behind the scenes, he expressed his appreciation of the help given him by his assistants, and their hope that the presentation of the Lecture had been a worthy tribute to Mr. Fletcher and his work on railway electrification.

MEASUREMENT AND CONTROL SECTION

Support for Fast Digital Computer

At the well-attended meeting held on the 4th February four papers were read dealing with nuclear reactor plants and their instrumentation. Mr. J. K. Webb, Vice-Chairman of the Section, was in the chair in the absence of Mr. H. S. Petch, and the meeting was held in association with the British Nuclear Energy Conference. The four papers are reviewed on pp. 249, 251 and 252.

The first paper was called *The Application of Digital Computers to Nuclear-Reactor Design* by Dr. J. Howlett. The author summarized the various mathematical methods which had been used, and discussed the machine developments of the future, concluding that faster machines (equivalent in performance to the projected American machines Larc and Stretch would be required.

The second paper, by Mr. J. H. Bowen and Mr. E. F. O. Masters, *Temperature Transients in Gas-Cooled Thermal Nuclear Reactors*, discussed the transient behaviour of the Calder Hall type reactor. The behaviour was studied in two ways—by an analogue computer and by a graphical method using an approximate solution of the neutron-kinetic equations, and it was shown that the graphical method can be a useful form of attack.

The final two papers were by Mr. W. Abson, Mr. P. G. Salmon and Mr. S. Pyrah—*Boron Trifluoride Proportional Counters* and *The Design, Performance and Use of Fission Counters*. The authors explained the use of these counters in detecting neutrons and measuring neutron fluxes, and their application in nuclear physics experiments and in nuclear-reactor instrumentation. The paper on boron-trifluoride proportional counters described how the various technological problems of constructing these counters in quantity had been solved. One phenomenon of special interest was that there was a deterioration in performance of the counter on extended use, owing to dissociation of BF_3 into BF_2 and free fluorine. However, when the counter is heated to about 180° C, the free fluorine is absorbed (the copper cathode acting as a getter for the fluorine) and the good performance is restored.

The discussion which followed was well up to the standard of previous meetings on nuclear instruments. Much of it was concerned with comparing the digital-computer and analogue-computer approaches, and with a detailed discussion of the assumptions made by Messrs. Bowen and Masters in simplifying their equations for use in their analogue computer. Clearly their simplifications could not always be supported, and the contributions to the discussion raised several examples where a more rigorous treatment was desirable.

There was much support for the development in this country of a fast British computer, and this was summed up at the end by Dr. Howlett, who clearly would like to get his hands on a British Larc or Stretch at the earliest possible moment.

Several people spoke on the last two papers. One pertinent point was that the sensitive material (boron 10 or uranium 235) was used in the gaseous form in the BF_3 proportional counter and in the solid form (^{235}U) in the fission counter. Clearly it would be possible to introduce the sensitive material in the alternative form—why was this not done? Mr. Abson answered this question by referring to the development of counters for operation at high temperatures; the present fission counter could probably be used at temperatures up to 500° C, but a change in design, possibly using elemental boron instead of BF_3 gas, would be needed in order to obtain equivalent high-temperature operation of the proportional counter.

There was also some discussion about methods of measuring neutron-flux distributions in power reactors, and the opinion was expressed that the d.c. ion chamber, designed to give a relatively large saturation current in order to minimize irradiation troubles, appeared to offer the best direct method of measurement.

The meeting closed with a few words from the Chairman thanking the authors and discussion speakers for their contributions to the meeting. D. T.

RADIO AND TELECOMMUNICATION SECTION

Transistors Made to Measure

During the decade since their discovery, transistors have maintained an unwavering popularity, and although on the face of it *An Inquiry into the Specification of Transistors* would seem to be merely a dull catalogue of characteristics, the

subject attracted a large audience and stimulated a lively discussion. This informal evening was convened by the Radio and Telecommunication Section on the 27th January, under the chairmanship of Mr. G. Millington, and the subject was introduced by Mr. F. F. Roberts.

The transistor specification is the outcome of consultation between the user and the manufacturer, and, ideally, should contain in precise terms all that is essential to enable the maker to produce units suitable for particular applications, and equally to enable the user to engineer his circuits with known margins of safety and reliability.

Mr. Roberts pointed out that a slack specification is not very helpful and that a tight one raises the cost of the product and is justified only in very special circumstances. A medium specification is most desirable, and was the one that he proposed to consider. Then, with the aid of many lantern slides, he outlined those characteristics of a transistor which it is essential to specify. These are:

(1) The ambient and junction temperatures allowable during operation in service and during acceptance testing of the transistor. (Germanium and silicon devices require separate consideration.)

(2) The low-voltage reverse-bias cut-off current.

(3) The maximum voltage as limited by thermal runaway, avalanche breakdown, punch-through and leakage. (The operational circuit configuration may greatly influence the test to be called for.)

(4) The current-gain for a specified range of currents.

(5) Bottoming or saturation voltage for specified currents.

(6) Some test for base resistance.

(7) Frequency response. (Common-base and common-emitter configurations, and finite generator and load impedances should be considered.)

(8) Collector capacitance or some related parameter, of importance in addition to (7) in neutralized circuits.

(9) Switching speed, if this cannot be covered by a suitable form of (7).

(10) Reverse-biased emitter characteristics, as required for class-B amplifier and switching-circuit applications.

(11) Noise figure at audio or higher frequency.

(12) Life-testing and general reliability.

Mr. Roberts's list was subjected to close questioning.

One speaker doubted whether all the factors mentioned were of interest in a specification; he thought that the user was expected to do too much and that the manufacturer should do more on his own initiative. On the other hand, the members present were warned not to be lulled into a belief that the specification on which Mr. Roberts had worked so hard and conscientiously was exhaustive; there were many more properties to be considered, and many committees considering them. This plea for even more rigid specification received support elsewhere in the discussion, but others were equally adamant that engineers should not let their physics run away with them when it came to testing; they should not try, in a specification, to cover every eventuality. It all reduced to a question of national economy in the end.

The statement that the collector-to-base breakdown should in some instances be tested at the highest junction temperature elicited the question whether the tests were intended to break the transistor, to which Mr. Roberts replied that some but not all tests were destructive.

A suggestion was made that with the drift transistor the minimum voltage below which it would not operate should be specified.

The extent to which specified limits may be exceeded was raised by a speaker, who said that cold-cathode tube circuits specified to run at 3 mA had worked well at 15 mA, provided they were not used at that current for long. Mr. Roberts said that voltage overload uses up the life of a transistor, but that not much is known about current overload, which may use up life even faster.

A complaint that British engineers had had to alter long-established ideas to follow the American trend produced the prompt answer from Mr. Roberts that he hoped the influence was not all one way and that there was at least some 'feedback'.

In the next phase of the discussion, a concerted attack was launched by the supporters of the manufacturing side. The manufacturer, said one, must pay for all the clauses in the specification. He also claimed that some of the clauses were vague. Asked by a 'neutral' member what percentage of cost was taken up by tests, a spokesman for the manufacturing side replied that they cost 'a good deal of money'.

On the other hand, manufacturers would not complain about Mr. Roberts's specification, which was a very simple and reasonable one indeed; being suitable for simple meter tests, it was appropriate for use on the factory floor. The number of tests should be kept as small as possible, and Mr. Roberts's specification ensured that this was so. The Americans might lead in transistor manufacture but not necessarily in transistor specification. Our ideas were not so backward as one would believe.

To a suggestion for intermittent tests, Mr. Roberts replied that what counted was the total time during which current was passed, not the number of switchings on and off.

Although the discussion was proceeding at a rapid pace, Mr. Millington had to bring the meeting to a close, with the observation that it was a good thing to end a party when it was in full swing. It had been one of the best and most spontaneous discussions for a long time. He did not claim to be an expert in the subject and still did not know the meaning of some of the symbols that had been bandied about (without definition) by the speakers, but they seemed to be keeping the meeting quite happy. Amid laughter the meeting broke up.

Pulsed Lecture

At the meeting of the Radio and Telecommunication Section on the 19th March, three papers were presented by Mr. K. W. Cattermole on some new concepts of pulse-amplitude modulation and pulse generation:

Efficiency and Reciprocity in Pulse-Amplitude Modulation Part 1—Principles, by K. W. Cattermole;

Efficiency and Reciprocity in Pulse-Amplitude Modulation. Part 2—Testing and Applications, by J. C. Price; and

Transistor Pulse Generators for Time-Division Multiplex, by K. W. Cattermole.

Mr. Cattermole had the formidable task of explaining in a very short time the basic principles of a method for converting an audio signal into an amplitude-modulated pulse train and back again into an audio signal, with low power loss, on a two-wire basis, and without the use of amplifiers.

These principles, which to the unenlightened would appear to smack somewhat of black magic, were explained with admirable clarity by the author. Not only were theoretical proofs given but, in Part 2, convincing experimental results were presented as well. Then, as if to persuade the few remaining unbelievers, Mr. Cattermole confessed that the

whole of his lecture so far had been given with equipment of the kind described inserted between his microphone and the sound reinforcement system of the lecture theatre.

The conventional method of pulse-amplitude modulation by signal sampling, and of demodulation by a low-pass filter gives a large overall power loss; for example, about 2 500: 1 in a 25-channel system. The system described, employing reactance storage (i.e. using reactors which charge and discharge at different rates) can be made with an overall power loss of less than 2 dB. Short reviews of the papers are published on pp. 255 and 258.

The author dealt with alternative designs for the critical parts of such systems, including some designs for optimum performance and others which compromised between economy and satisfactory performance. In discussing the possible applications of his system, he said that probably the most promising field was that of electronic switching.

Opening the discussion, Mr. T. H. Flowers drew attention to the fact that the idea of pulse-amplitude modulation using reactance storage had been studied and developed simultaneously and independently at three different places; at the author's laboratories, at the Post Office Research Station, Dollis Hill, and in the United States. He agreed that the chief use of the system described will be in the field of electronic switching, but felt that the experimental evidence given in the papers was not sufficiently complete to enable a fair comparison to be made with other systems also under consideration in Great Britain.

The matter is of considerable importance since decisions must be made in the next year or two concerning future electronic-exchange systems.

The possible difficulties in meeting a sufficiently high transmission performance were mentioned by one speaker, and another wondered why pulse generators employing point-contact transistors had been used when such transistors are now practically obsolete.

In answering these and many other comments, Mr. Cattermole showed the same skill and clarity of expression that he had shown during the reading of the paper. L. I. F.

SUPPLY SECTION
MEASUREMENT AND CONTROL SECTION

After the more general paper presented earlier in the session on the application of digital computers to transformer design, the paper read at the joint meeting of the Measurement and Control Section and the Supply Section on the 12th March illustrates how computer analysis is penetrating into all branches of design calculations.

The paper was called *A Method of Analysis of Transformer Impulse Voltage Distribution using a Digital Computer*, by Beryl M. Dent, E. R. Hartill and J. G. Miles. A short review appears on p. 259.

Applications of the kind described in this paper require expert knowledge of: (*a*) the electrotechnical problem to be solved and the information required, (*b*) higher mathematics for expressing the problem in a suitable form, and (*c*) computer technique and operation. The authors of the paper each represented one of these divisions, with the result that all aspects were competently and authoritatively handled, not only in the paper itself but also in the authors' presentation and subsequent replies to the discussion.

The main purpose of the paper is to show how the standing-wave theory of impulse voltage distribution, which has been applicable hitherto only to simple uniform windings and rectangular or unit-function waves, can with the aid of the digital computer be extended to cover practical non-uniform windings and incoming impulses of any usual form whether full waves or chopped.

One criticism in the discussion was that, although the authors should be congratulated on this achievement, they had given practical examples only of measurement on simple uniform windings and with rectangular waves, and thus they had not done full justice to their work or to the capabilities of their method.

It was also suggested that, although the figures for time and cost of computer operation were factual, both could be reduced under more convenient operating conditions and thus improve the authors' economic case.

The discussion generally concerned the relative merits of standing-wave and travelling-wave theories and the economics of computer availability for *ad hoc* calculations. In a paper dealing with so specialized a subject the discussion was necessarily mostly in the hands of experts, who were thus able to enjoy an intimate interchange of views. E. T. N.

SUPPLY SECTION

The Performance of Paper

Irrespective of the nature or guise in which paper insulation appears as a subject for discussion, the meetings at which it forms the subject are well attended and lively, and the one held on the 29th January fulfilled expectations. The condition of synthetic-resin bonded paper which has been rolled up to contain metal foils to form high-voltage switchgear bushings, and which has been in service for a few decades, has been examined by Mr. J. L. Douglas and Mr. A. W. Stannett, and the results are included in their paper *Laboratory and Field Tests on 123 kV Condenser Bushings*, a short review of which appears on p. 261.

The discussion was opened by Mr. F. C. Walmsley, who welcomed the information on site tests and criteria, but felt that the shortcomings of a few obsolete bushings, made at an early state of the art, should not give rise to overall fears now that their nature is known.

Dr. J. S. Forrest submitted that the authors' work had elucidated phenomena which had been troublesome in dielectric-loss measurements, and he went on to indicate the economic factors relating to outages and the limited extent to which site testing could be performed.

A considerable contribution on results obtained on bushings removed from service was made by Mr. P. G. Ashley, who also gave many practical points relating to reconditioning. He took pride in the low failure rate indicated and felt that a high standard of manufacture exists in this country.

Amid laughter, Mr. W. J. Brown associated himself with the closing remarks just made and ably expressed his views on past practices in testing, contending that even now tradition and custom appear stronger than reason.

The supply interests represented by Mr. D. M. Cherry and Mr. W. G. Todd were then presented, the former speaker indicating that he regarded the paper as a statement on the health of the bushings installed and that radiography could usefully supplement the power-factor/voltage tests already strongly advocated. Mr. Todd paid tribute to the excellent spirit and co-operation which existed between the various bodies on the supply side, resulting in the present paper.

The discussion, having so far ranged through the art of the manufacturers and the views of the users, then turned to the approach made by the scientists. Dr. J. H. Mason analysed some of the findings, especially the question of the relationship of loss measurements to the quantity of discharge present, indicating that some small measure of discharge would not necessarily prove deleterious in service. Mr. N. Parkman, with some quick-fire quasi-mathematics, presented his views on some of the observations made, but a number of listeners remained unconvinced of the validity of his arguments.

From the cloisters of the research laboratory the audience were hustled back to the outside world of the user by Mr. C. W. Mott, who in thunderous and almost sulphurous terms proceeded to demolish any complacency the manufacturers may have gained. He simultaneously rejected any extension to site testing programmes whilst pleading for an improvement in bushings by a change in the materials employed.

Mr. W. A. Cook, making an apt analogy between the early bridge builders' lack of knowledge of metal fatigue and the bushing designers' ignorance of discharge erosion, challenged Mr. Mott whether bridge building should cease!

The impression was obtained that the authors were well satisfied with the torrent they had loosed, and in his reply Mr. Douglas stressed the objective of providing useful information and data to establish a spares stock level. He dilated on the vexed question of detection of discharges, but emphasized the importance from the users' side of a ready means of determining the suitability of a bushing for further service.

In his inimitable style, the Chairman, Professor M. G. Say, remarked upon the excellent and well-supported discussion and cordially thanked the authors. F. C. W.

NEWS *from the Centres*

MERSEY AND NORTH WALES CENTRE

In the course of time the Faraday Lecture has become an established and popular feature in Liverpool. In view of the great demand for tickets, distribution has been a difficult problem for some years, and it was most helpful of Mr. R. Ledger to present the lecture twice on the 6th March in the Philharmonic Hall. An audience mainly of younger people from schools in South Lancashire, Cheshire and North Wales were entertained and instructed by a special presentation in the afternoon. After the very polished performance in the evening, the pleasure and thanks of the audience were gracefully expressed by Dr. Dennis Chapman of the Department of Social Sciences at Liverpool University.

Dr. Willis Jackson had a full attendance and a searching and lively discussion when he visited the Centre in February to consider the report on *The Supply and Training of Teachers for Technical Colleges*.

The annual golf tournament is to be held on Tuesday, the 17th June, once again on the course of our very good friends of the Southport and Ainsdale Club. E. W. A.

OVERSEA ATTENDANCE REGISTER

During the period 17th March to 16th April 1958 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

ASCHMAN, G. D. (Hobart, Tasmania)
BAILEY, J. P. (Malaya)
BENNETT, J. M. (Sydney)
DAWSON, F. W. (Perth)
DE ZOYSA, E. W. (Colombo)
HIGGS, P. J. (Ottawa)
LAMB, C. St. L. (Sydney)
LORD, W. R. (Tanga, Tanganyika)
MARTIN, A. J. H. (Brisbane)
MELLANBY, J. (Ghana)
POULSEN, A. B. (Brisbane)
SPALL, R. D. (Tanga, Tanganyika)
SUMPATHKUMARAN, K. P. (Madras)
SUTTON, F. W. (Nairobi, Kenya
WILLIAMS, A. T. (Melbourne)

WHO IS THIS ELECTRICAL PIONEER?

The portrait on the right was recently acquired by the Burndy Library, Connecticut, but it has so far defied all attempts to identify the sitter, and it is hoped that readers of the *Journal* may be able to help.

The artist's bold signature at the bottom of the painting reads: 'Painted 1838. T. H. GREGG, Upper Fitzroy Street, Fitzroy Square', and this name and address is repeated in the letter and envelope shown on the table.

From the Leyden jar held in his left hand and the Henley electrometer in his right, the sitter would appear to be an early experimenter in electrical science. Pneumatic apparatus rests on a table at the left. The florid complexion, full features, youthful eyes but greying hair, seem to indicate a person about 40–50 years old.

Various authoritative sources in the United States and London, including the National Portrait Gallery and the Science Museum, have been unable to name him. A search of the records of the artist's London exhibitions was likewise unsuccessful.

If any reader can provide information about the sitter which will help in tracing his identity, he is invited to write to Mr. Bern Dibner, Burndy Library, Norwalk, Connecticut, or to the *Journal*.